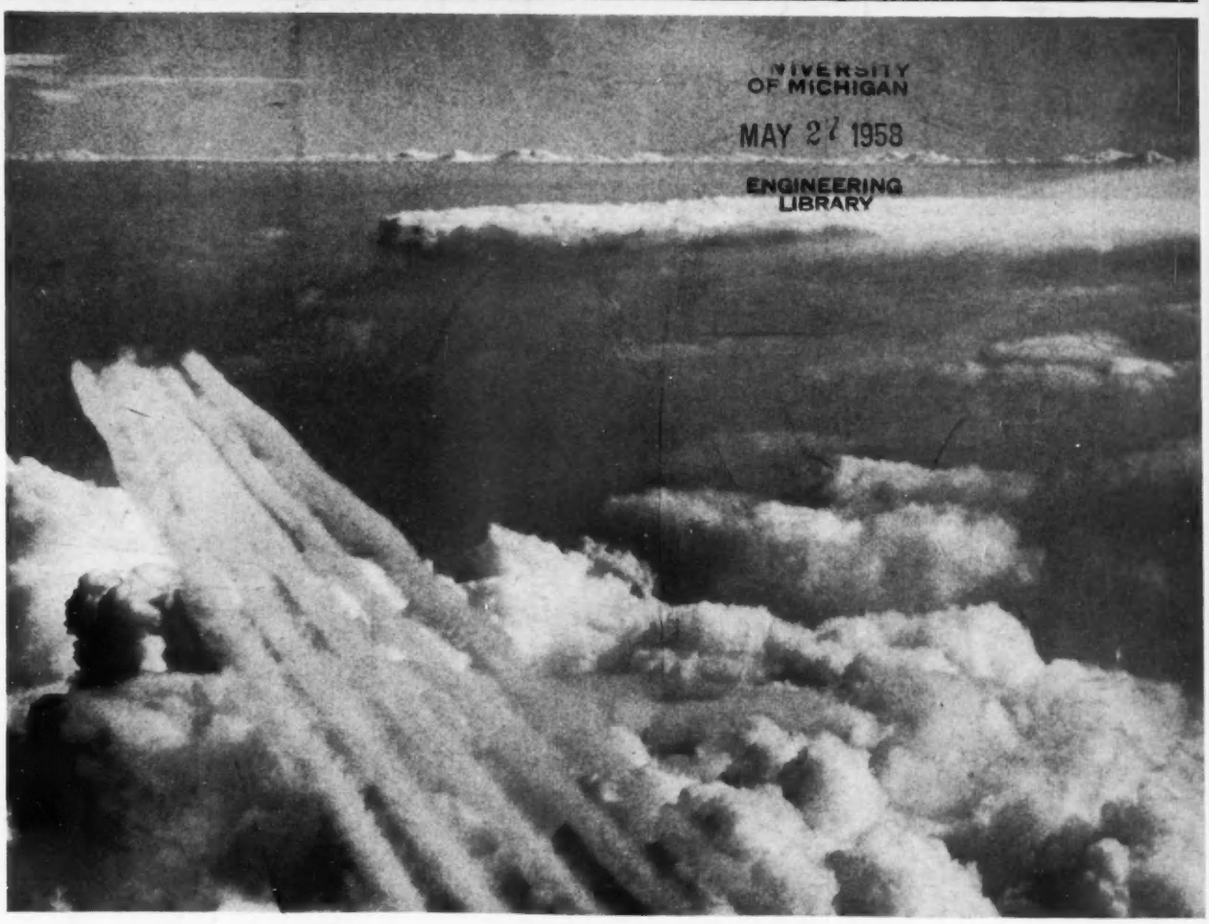
ENGINEERING

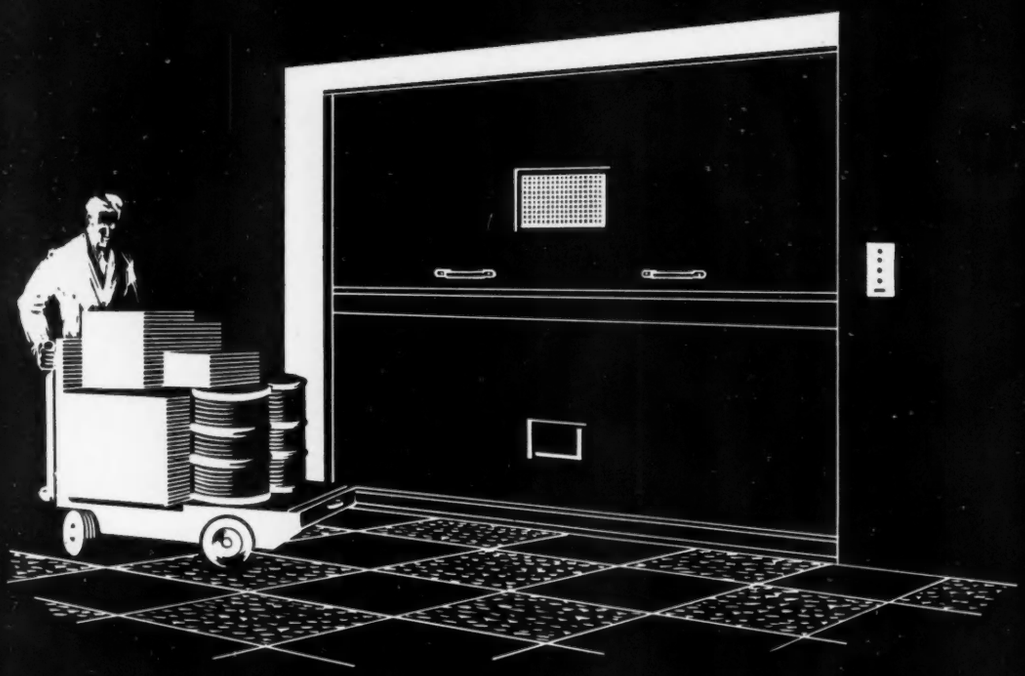
his issue

ages 593 to 604 :—


NIVERSITY
OF MICHIGAN
MAY 27 1958
ENGINEERING
LIBRARY

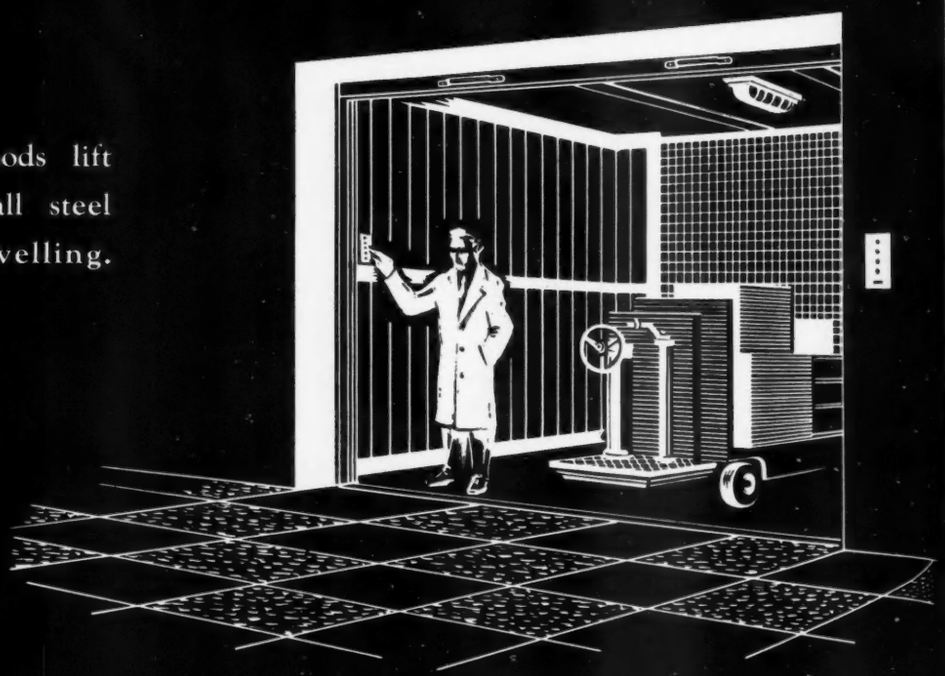
Report of "Engineering" Inquiry into the British Aircraft Industry

PICKERINGS LIFTS



ESTABLISHED 1854

Heavy duty industrial goods lift with vertical rise and fall steel doors, and automatic levelling.



Ward Leonard — Collective Control — 2 speed and economical single speed passenger lifts — Goods lifts up to 10 tons — Electric and hand-power service lifts

PICKERINGS LIMITED · STOCKTON-ON-TEES

Sales and Service Branches:- **116 VICTORIA STREET · LONDON S.W.I.** *Tel. Victoria 9860*

also at BELFAST · BIRMINGHAM · BRISTOL · DUBLIN · GLASGOW · HULL
LEEDS · MANCHESTER · NEWCASTLE upon TYNE · SCARBOROUGH · WORTHING

Vol. 185 No. 4809 9 May 1958

ENGINEERING

PUBLISHED EVERY FRIDAY

Contents

577 **Leading Article**
One of Ours

578 **Plain Words**

579 **Letters to the Editor**
Workshop Psychology
Supporting Research Associations
Undergraduate Training in Nuclear Power
Practical Training of Engineers
Railway Renaissance

583 **Notices of Meetings**

584 **Companies in the News**

585 **Book Reviews**
Some Applications of Behaviour Research

585 **New Books**

585 **On the Shelf**

Special Articles

586 550 MW is Reached: Cross Compound Turbine

593 REPORT OF "ENGINEERING" INQUIRY INTO THE BRITISH AIRCRAFT INDUSTRY:
594 Aircraft Companies Look at Policy and Action
598 How the Aircraft Companies are Responding
601 New Products
602 Making the Changeover
603 A Comment on Aero-Engines

589 **Atomic Review**
New Research Facilities

591 **In Parliament**

608 **Engineering at Home**
Integral Light-Alloy Caravan

578 **Management**
Weekly Survey

580 **Plant and Equipment**
Piercing Hard Metals
Polyethylene Hose
Sheet Metal Fixing
Transporting Oilwell "Mud"
Variable Speed Motor Drive
Steel Without Smoke
Handling Heavy Parts for Machining
Mechanical Handling: 1 Torque-Transmission, Trucks and Loaders

587 **Metals and Materials**
Fifty Years of Metallurgical Service
Co-ordination of Research into Deep Drawing

588 **Marketing**

592 **The Human Element**

605 **Design**
Bending of Pre-Twisted Turbine Blades: Effect Of Inclination of Longitudinal Fibres
Control of Back-Pressure Turbines: Speed and Pressure Systems
Eastern Region Diesels
Scanning Correlator for Aerial Surveying

One of Ours

THE uncertainty which has bedevilled the aircraft industry since the Defence White Paper was published over a year ago should be cleared away when the Minister of Supply reports the findings of the inter-departmental committee which has been studying future Government policy towards the industry. This lively industry is hoping for continued Government support, particularly for aeronautical research, on a scale comparable to that which it has enjoyed in recent years, but whether or not these hopes are fulfilled the immediate and pressing need is for a clear statement of policy. Forward planning, so important to such a far-seeing industry, has to be suspended until the statement is made. During the past few weeks ENGINEERING has sought information and opinion from the aircraft builders. We have talked to many of the engineers and policy-makers of the industry, and a 12-page report on these talks is published in this issue.

It has been widely assumed that the White Paper foreshadowed the end of manned military aircraft. That was a false assumption which has only added to the general uncertainty. Mr. E. C. Bowyer, director of the Society of British Aircraft Constructors, has interpreted the White Paper as indicating that the Government were contemplating some seven or eight new types of manned aircraft to remain in service for a considerable time, in addition to the full development of the V-bombers and the P.1 fighter, and new military transport aircraft. But the industry is still waiting for the specifications.

By any standards but its own the aircraft industry has been accustomed to an artificially high rate of technical development. Except for the atomic energy industry, no other branch of engineering has been so spoilt with finance. A substantial proportion of our best engineers, scientists and technicians devote the most creative years of their lives to its service. If we compare its rate of development with that of the two other transport industries—shipping and railways—there are two possible conclusions: either shipping and railways are absurdly slow in development (considerations of safety can be ignored because they apply with at least equal force to airlines), or aircraft have been given preferential treatment. Probably the truth lies partly in each conclusion. Certainly aeronautical laboratories, design offices and workshops have been lavish by normal engineering standards.

Early in the 1940's, when time and money spent on research had to be fully justified, basic research on transonic and supersonic research started in this country. Fortunately for our prosperity, it was continued in spite of the doubting Thomases who believed that such speeds would remain beyond reach because piston engines could not possibly be developed to give enough power for weight. The imminence of gas-turbine aero-engines was foreseen by few at that time. The long-range guided missile, also, seemed a hopeless weapon of war during early research because of its inaccuracy. Experts are sometimes the most unreliable judges of technical projects; given the time, the money and the drive, almost all projects can succeed.

Engineering thrives on the "impossible." Leave it to the faint-hearted, the unimaginative, and the cautious—expert or administrator—and it might take us a long way in a long time. Ask it to work miracles, to achieve the impossible and to embark on a venture the end of which is not in sight, and it will not only succeed, it will also foster by-product ideas and techniques which go out into all industry and inspire new developments that nobody in his wildest dreams could have foreseen. For 40 years, on and off, the aircraft makers have had that opportunity; and right well they have used it. They have refined methods of design to an unprecedented degree, demanded and obtained new alloys and non-metallic materials, led the way in new machine tools and machining techniques, extended the frontiers of aerodynamics, hydrodynamics and allied sciences, fostered the development of radio and radar, developed the art of directing highly complex projects involving everyone in an engineering organisation from research to sales, and given successive generations of scientists and engineers unique opportunities to practise their profession. In short, the aircraft industry is a vast national laboratory—a laboratory which sets no limits to imagination and the possible, yet escapes the charge of being too far removed from practical engineering. Around the periphery of the aircraft industry, too, there are firms and groups of firms who co-operate in the work of several branches of engineering, including aeronautical, and thereby help to channel the results of advanced research and practice to industries which, left to themselves, would move at a slower pace.

The industry which plays this dominant role in our economy, and which builds airliners that are ahead of foreign competitors, is every engineer's concern. It is one of our special industries. The Government's statement on future policy will show whether they comprehend the nature of modern engineering and its power to guarantee the future of Britain.

Plain Words

Into my office this week came a copy of the special sixtieth-anniversary issue of a great little magazine. On the front cover it carries a picture of the silver model of the Rocket which the late Dr. Bradbury Winter built, and inside there are articles by some of its famous contributors—articles reminiscent and practical—together with messages of good wishes, including one from the Duke of Edinburgh.

Model Engineer has carried the spirit of practical engineering, which was so lively when the paper was founded at the end of the Nineteenth Century, into the age of scientific engineering. It wisely ignores those rather artificial barriers between the professional engineer, the craftsman and the amateur, and unites them all in a common affection for model engineering. Models are not the whole of model engineering, however; an article on the design and construction of a splendid electric clock shows that the true interest of readers lies in engineering on a scale which is appropriate to a small workshop.

I am sure that, if they had the production facilities, most model engineers would not restrict their work to models—they would love to build a full-size locomotive or traction engine. As it is, they tackle something that is within the scope of their small lathes and the marvellous assortment of hand tools which they acquire over years of model engineering. Depending on the time they can spare for their hobby, they may undertake the building of a model which they can finish in a year or two, or, like one model engineer I know, they may spend twenty years or more on a large model which not only looks an absolutely faithful model of the original but is also a faithful copy of the production methods employed for the original. A model of that kind is high-quality mechanical engineering.

In my view, one of the most important contributions of the practice of model engineering is that it counters the inevitable tendency for engineering to become more and more a team effort. In the industrial world the direction of teams is a prime interest. All the paraphernalia of management is employed on its behalf. The lone worker, especially the lone creative worker, has a thin time. But in model engineering he can find his dream world of engineering. He is his own chairman, managing director, chief engineer, chief designer, works manager, foreman, charge hand, turner, fitter, inspector, and tester. He doesn't employ a sales manager or a publicity manager—fortunate fellow! He doesn't draw a salary—indeed he has to spend money on his engineering—but he probably gets more satisfaction out of his work than many an engineer engaged as a member of a team on an important contract. Small wonder that there is a weekly magazine to serve the interests of such engineers. May it prosper; and with it the domestic art of model engineering.

CAPRICORN

Weekly Survey

Research and the State

In his presidential address, "Science and the State", to the Institution of Chemical Engineers, Sir Hugh Beaver has drawn attention to the cumbersome and *ad hoc* administrative structure by which the State controls, or at least tries to influence, the trend of research. He points out that through the maze of grants, advisory committees and departmental responsibilities, the Government has little opportunity to drive anything that can be called a long-term policy. He goes so far as to wonder if there ever has been a policy. He points out the limitations of committees, which can report but hardly ever initiate action, and he draws attention to the limitations of the DSIR. He has much to say in favour of that admirable institution but he thinks that it can hardly be expected to be an efficient instrument of Government policy in the rapidly changing world of to-day when it was conceived over 40 years ago while this country was at war.

Having queried both the will and the means of a national research policy (using research in the widest sense of the word) he goes on to emphasise that in the modern world Government must, by the nature of things, control research. Whatever may be one's views about State control and private enterprise, he sees no alternative to Government willing both the end and the means of a high rate of technical change in industry with all that goes with it in so far as fundamental and applied research is concerned. Part of the means which must be willed, in his opinion, is a greater supply of teachers.

There will be general agreement with much of what Sir Hugh says. Our research effort has all along been piecemeal and *ad hoc*; nevertheless, particularly on fundamentals we have achieved more than most at relatively little cost. In a way, the problem is even more difficult than he would suggest, for this country must try to steer a middle way between the present untidy jungle and a vast bureaucratic machine which will all too quickly come to behave as an end in itself. There is much that can be said in criticism of the present ill-disciplined levies but in a crisis they might be rather better than a Prussian army which is magnificent to look at but cumbersome in action.

Small Car Sales Drive

A record output figure was achieved by the motor-car industry for March when 100,000 cars were produced for the first time. In the first quarter of this year the annual rate of output of the industry was 1·1 million units a year and exports, at just over 132,000, were nearly half as many again as a year before. It is expected that the home market will this year absorb more than 500,000 cars, a figure of new registrations which has not been reached since 1955.

The feature of the export boom has been the continued strength of the United States market which took nearly twice as many cars in the first quarter of this year as in the same period of 1957. In the first quarter exports to the United States amounted to 28 per cent of total shipments. Much of the car boom comes from the high sales of small cars, small at least by United States standards, despite the general recession in the local automobile industry. Nevertheless, while the large automobile makers in Detroit are still reducing work at many of their plants, the American Motors Corporation is taking on additional labour to increase the output of its Rambler car which is the most successful of the small horse-power cars made in America.

There are also reports that General Motors are planning to make a small car soon. These rumours have been generated from the American machine tool industry which has had inquiries for large supplies of machine tools for a small horse-power car from G.M. It has been suggested that the tools are wanted for its Australian Holden car, but rumour persists that the company is planning a small car to be made in the United States for the American market. If this should be true it would confirm statements made in some quarters that the importation of small European cars has been stimulated by the large United States automobile makers to test the market. While all this may be true, the general export performance of British cars continues encouraging. For example, United Kingdom models are now holding their own in the Swedish market which swung over to German models in a big way a few years ago.

Dollar Loans for Atomic Power

Negotiations have been going on between this country and the United States for raising a dollar loan for the erection of atomic power stations here. If the loans were raised for this specific purpose there would be the advantage that the charge would be against a resilient industry in which this country has a useful technical lead. The dollars would, of course, be a useful addition to this country's foreign exchange reserves. There are reports that the amount under discussion ranges between 50 million and 100 million dol.

There are precedents for this kind of activity by the World Bank in Europe and it may be that any arrangement would follow the usual pattern by which the World Bank participates in specific schemes which are backed in part by local finance. The World Bank is opposed in principle to "going it alone" in matters of investment in any particular country. Another complication is the extent to which money of this kind should be raised with the World Bank's co-operation and how far such an arrangement could be used as a means for raising a dollar loan in New York. The recent trend of interest rates in the United States makes it increasingly likely that this country could raise a loan from the New York capital market on slightly better terms than those which could be obtained from the World Bank.

Federation of the Islands

The Federation of the West Indies is now fact. No matter how slow the political consequences to the individual members of the act of unity may be in working themselves out, a new era has opened in the economic development of the Caribbean.

The British West Indian market is one which, according to many reports, has been underestimated and systematically ignored by British manufacturers. One consequence of this has been the increasing influence of the United States. Nevertheless this country is more important in the Federation's trade than either the United States or Canada. In 1956 the combined import and export value of the Federation's trade with the United Kingdom was about 320 million dol compared with 135 million dol with the United States.

The federated islands have a population of only three million scattered over a wide sea area. There is almost 1,500 miles of sea between Grand Cayman and Trinidad—the extremes of the Federation. The whole area needs more intensified agriculture, better shipping and air services, improved refrigeration facilities and new secondary industries—all of which means increased amounts of capital. The fact of federation is likely to throw these problems into further relief and make the British West Indies increas-

ingly vocal in their demands for British capital and trade. Especially will this be so as the Federation approaches the time when it will be able to achieve full Dominion status in five years' time.

Help for the Ambitious

To attract, develop and retain high calibre employees is the aim of most engineering companies. In the case of General Electric of America it has led to the formation of an elaborate organisation which provides almost anything a good man can wish for, from post-graduate research to loans, health insurance and an Emergency Aid Plan. In their résumé of the past year's activities, General Electric give details of the many schemes they operate to ensure they get and keep their share of available talent. In a company so large—their employment during 1957 averaged 282,000—there is a vital need to build up research and management teams at all levels and to avoid the kind of waste which results from good staff being employed in the wrong jobs. General Electric, the report states, "seek to provide every individual the opportunity to develop his usefulness to the utmost, commensurate with his own interests, capabilities and initiative."

New factory employees are offered special orientation programmes and training in specific factory operations. Experienced factory employees are given "on-the-job" training so that they may prepare themselves for more advanced jobs. This is done on an immense scale, to ensure that anyone who wants to can get the training needed to handle the wide variety of jobs within the group. An apprentice training programme at 29 plants has provided 2,000 high school graduates, who had good technical capacities, with training in advanced factory, skills, and 500 have followed special work-and-study courses to qualify for college degrees. Young technicians are encouraged to advance towards careers as laboratory or engineering technicians; foremen are given opportunities to take courses in supervisory practices; companies in the group are authorised to make loans up to 1,000 dol a year to employees or their children for their higher education and there are other schemes carefully designed to help factory workers, apprentices and technicians to make good.

General Electric also carried out a comprehensive programme of study and training for graduates. These include professional programmes of one to three years duration designed to develop abilities in a wide field of endeavour, including advertising, engineering, marketing, physics, and public and employee relations. An Engineering Honours Programme (established in 1956) enables graduate engineers to work for advanced degrees, at no cost to themselves. The report quotes an estimate that in 1957 "one out of every eight G.E. employees advanced his self-development through participation in one or more of the company's educational programmes." Quite apart from the fact that the G.E. provide in addition a most comprehensive welfare service, their activities in the field of education should ensure that they attract, and keep, high-calibre employees.

Cross Currents in Steel Tubes

Since the rate of increase in the expansion of the world oil industry, notably in the United States, has eased off noticeably in the last 12 months the outlook has become somewhat confused. The world steel-tube industry is having to make some fairly substantial short-term adjustments. The impact of the world situation on Stewarts and Lloyds was commented upon in a note in ENGINEERING on these pages last week. The dampening down of furnaces at Corby will be a passing phase. A much more serious casualty, brought about to some extend by current depressed conditions, is the closure of the Metaalbuizenfabriek Mij Excelsior (Schiedam) in Holland after it had been working for about one week. It cost about £12¼ million to complete. The mill has a potential capacity of about 70,000 tons a year of thick-walled electrically-welded tubes and cold seamless tubes. Severe competition has been encountered from Belgium and since the European Common Market will expose Holland (which until this mill was installed had no steel tube industry) to the full rigours of competition from both Germany and Belgium, the long-term outlook for this mill is already somewhat problematical.

Not all the talk is of contraction however. In Italy a state-sponsored group has established a company with the Armco Steel Corporation of the United States, to be called Armco-Finsider, to complete a tube works near Naples for operation in 1959. In Austria also a seamless tube mill is to be erected by the close of 1959 by Schoeller-Bleckmann to make seamless tubes (including high alloy) with an annual capacity of 30,000 tons. There is thus a good deal of capacity planned for installation next year. The plans are doubtless based on the long-term expansion of the oil and natural gas industries. Despite temporary and perhaps violent changes in the market for tubes, the long-term prospect is still a sound one.

Lloyd's Register

The annual report of Lloyd's Register of Shipping for 1957 contains much that is of interest to the engineering world, especially since they are increasingly concerned (through their Land Division) with the safety and therefore the certification of plant used in the production of oil, chemicals, atomic energy and other products involving danger to life if high standards of construction and maintenance are not strictly enforced. Few bodies of this kind have built up so fine a reputation and are in such keen demand throughout the world, whether across the Atlantic, in the Far East or behind the Iron Curtain.

Mr. Pelly's survey of the past year ranges widely over the marine and industrial field. They have expanded their facilities in the shipping industry by opening new offices in Denmark and Finland. At the request of the Polish Government they have returned to Poland and established exclusive offices in Gdansk and Katowice, and opened a new office in Baghdad to deal solely with Land Division duties. In the technical field the Register report the introduction of a new specification for steel suitable for welded ships, to be adopted next September. Another noteworthy development which is going on under the Society's survey is the conversion of a ship for the carriage of liquefied methane. If this proves practicable, Mr. Pelly says, it will "open the way for a considerable trade." Concerning the allegation so frequently heard that ships sailing under "flags of convenience," are below standard in crew accommodation, carry excess tonnage, etc., Mr. Pelly is quite unequivocal in his statement that "ships classed with Lloyd's Register which sail under 'flags of convenience' are required to conform to the Society's standards." They have issued certificates in the case of some 720 ships registered in "flags of convenience" countries.

The Society look to atomic energy as the greatest single source of expansion for the future. Since the beginning they have been involved through their Land Division in the inspection of reactors and power plant. They have assisted the UKAEA in feasibility studies of the nuclear propulsion of large tankers and have concluded that it is possible to install gas-cooled graphite-moderated reactors in supertankers, but "that there are considerable problems to be overcome before the overall costs of gas-cooled reactors can compete with those of average conventional marine plants."

Letters to the Editor

WORKSHOP PSYCHOLOGY

SIR, I found your Plain Words (25 April, p. 514) very interesting, but I should like to suggest that there might be mentioned additionally the psychological value of shop training. This is obtained only by experiencing the working conditions which are the life environment of skilled mechanics whose co-operation is essential in putting into practice the ideas of the professional engineer. In engineering, as in other professions, a satisfactory human relationship must first be established before any professional ideas can be communicated, and this aim is more likely to be achieved when the engineer has had workshop training.

As an example of this principle, when I was nearing the end of my apprenticeship many years ago, the foreman, who was my instructor, explained that, although I had worked in many different shops, before I finished my apprenticeship I had to learn one useful lesson more. He said "You must learn how to idle without being caught by the foreman, because one day you will want to know how it is done."

Yours faithfully,
P. V. HOARE.

The Knoll,
Morcombelake,
Bridport,
Dorset.
28 April, 1958.

SUPPORTING RESEARCH ASSOCIATIONS

SIR, In your issue of the 25 April (p. 515), Mr. S. B. Bailey commented on my speech in the House of Commons when I criticised the failure of so many engineering firms to support the Production Engineering Research Association.

Of course, I accept his argument that the probable benefits must be balanced against the membership fee, but I cannot help feeling rather sceptical as to the extent to which this has really been done on a large scale among the firms which have not joined. If it had, I am sure there would be many more than 520 members. In the course of the television interview to which I referred, a spokesman of PERA estimated that some 10,000 firms could very well benefit from membership and at least half of them were what he regarded as potentially first class members, i.e., sizeable firms that ought to be in the Association without delay.

Annual records of the Department of Scientific and Industrial Research have given examples of firms which have saved thousands of pounds per annum by applying techniques developed by the Association. Even if there are many engineering firms that would get no benefit from the work done by the Association so far, or the work they are likely to do in the next year or two, surely we cannot avoid the conclusion that a very much larger proportion of them would benefit than the small percentage who are in membership, and that this is an example (unfortunately not the only one) of the backwardness of a large part of British industry in applying new techniques.

Yours sincerely,
R. E. PRENTICE.

House of Commons,
London, S.W.1.
29 April, 1958.

UNDERGRADUATE TRAINING IN NUCLEAR POWER

SIR, I would like to comment on the letter from Dr. N. S. Grassam in your issue of 18 April (p. 483). I agree entirely that some fundamental training in the concepts of nuclear power should be available for undergraduates generally. It is important, however, that instruction at undergraduate level should be kept to the absolute minimum to avoid further overloading of the

Continuing Letters to the Editor

syllabus. At Imperial College introductory lecture courses have been given since October, 1956, to third year mechanical engineering students. The article on "Fundamental Training in Nuclear Power," published on p. 394 of your issue of 28 March, was concerned primarily with the post-graduate course at Imperial College for the reason that this course is being held for the first time during the current academic year and includes certain features which may be of general engineering interest. It is not suggested, however, that all university engineering departments should concentrate attention on post-graduate courses.

Yours faithfully,
J. M. KAY,
Professor of Nuclear Power.

Department of Mechanical Engineering,
Imperial College of Science and Technology,
London, S.W.7.
30 April, 1958.

PRACTICAL TRAINING OF ENGINEERS

SIR, I was very interested in Capricorn's column in your issue of 25 April (p. 514) in which he discussed practical training for professional engineers.

In the middle 'twenties, I was fortunate enough to spend three years as one of several graduate pupils in a works of considerable repute. For my part, I would not have spent those years otherwise. During that time, we were able to study not only what mechanics did and how they did it, but a number of other—and, possibly, more colourful—trades, such as smiths, pattern-makers and moulders. Possibly, the relative importance of some of these may have changed since then, but it would be sorry indeed if anyone who made one of these short, potted sojourns into the shops got the idea that things started in the machine shops or on the fitters' benches, where the mechanic is seen in all his glory.

Obviously, it was neither possible, nor intended, to make us into craftsmen, but we all developed a lasting regard for these good folk and their many skills. But, with great respect, I would suggest that possibly one of the greatest advantages a young engineer should obtain from a long sojourn in the shops is not so much a knowledge of the technical aspects of these various callings, but a close insight into what nowadays is probably called the psychology of labour.

By living and working intimately with all kinds in a large factory, a young man, still in the formative stage, sees and feels, at close quarters, many of the fears, taboos, shibboleths and jealousies—besides the many very endearing qualities—of ordinary workpeople.

For those who, in later years, are called upon to manage manual workers, this experience should prove of immense value in fostering harmonious relations in industry.

Yours faithfully,
CHRISTOPHER BELL.

8 Magpie Hall Lane,
Bromley, Kent.
1 May, 1958.

RAILWAY RENAISSANCE?

SIR, The leading article in your issue of 2 May, which finally developed into something of a homily on the waywardness of various elements in British Railways, ended with a reference to myself and the Railway Conversion League that was, perhaps, out of context; for we sincerely sympathise with railwaymen of all grades, and are only anxious, at this stage, to dispel the wrong thinking that has saddled them with the task of bringing about a railway renaissance. In fine, we are not chasing the railways; we are chasing errors in reasoning and, more particularly at this moment, false premises.

In which connection, and so that I may not beg the question, let there be instanced the "tenet of many politicians and union officials," quoted in your leading article, to the effect that Britain is enjoying cheap internal transport—too cheap to provide adequate railway wages.

Britain's internal transport cheap! Most of it is road transport, the bare cost of which admittedly may be low: the price at which it is enjoyed, however, is something very different: it includes about £400 million a year net to the Exchequer and more than £500 million a year lost in delays due to a woefully inadequate and defective highway system—on which point the Highways Conference of the Institution of Civil Engineers, held last November, left no room for doubt whatsoever. A form of transport carrying two such large, artificial imposts can never be deemed cheap by absolute standards. If it is deemed cheap by railway standards then plainly the railway standards of pricing are too high—not too low: an absurdity is reached: that tenet is completely untenable.

The only safe tenet, in the common weal, is that all transport takes too long and costs too much. With that as a starting point, the Railway Conversion League argue for the provision of a comprehensive system of motor roads that will eliminate those £500 million road traffic delays. Were such a system provided, road transport would at once rob the railways of the last of their traffic: quite logically, therefore, the League argue for the motor road system to be provided by the conversion of the railway system.

Yours faithfully,
T. I. LLOYD,
Brigadier.

Railway Conversion League,
123-124 Newgate Street,
London, E.C.1.
5 May, 1958.

Plant and Equipment

PIERCING HARD METALS

A tap or drill broken off in the workpiece is always an annoyance and often a difficult item to remove. A machine designed for this particular purpose, but which can equally well be used for drilling and piercing any hard metal, is the Disintegrator marketed by Marbaix Industries Limited, Vicarage Crescent, London, S.W.11.

Broken taps or drills can be removed by the Disintegrator which can also cut holes of any shape in most metals.

The operation is primarily an electrical one, the tool electrode burning its way into the metal and being slowly consumed at the same time. The hole cut is the exact shape of the electrode, so it is equally easy to cut round, square or star-shaped holes in any metal through which a current can be passed. For example, holes of $\frac{11}{16}$ in diameter were cut in $\frac{3}{8}$ in thick 14 per cent manganese steel at a rate of 8 minutes per hole. In this case a hollow electrode was used.

The model illustrated, the M58C, is a self-contained unit with the electrical equipment mounted in the base with the coolant tank and pump. The work table measures 26 in by 26 in by $1\frac{1}{2}$ in and has four T slots. The operating head is mounted on a tubular steel column. The unit is transportable and runs off the standard mains supply either at 200/250 or 400/440 volts single phase a.c. 50 cycles. The consumption is about 2 kVA. Electrode consumption is about one-third of the depth of cut.

POLYETHYLENE HOSE

A new polyethylene-lined rubber hose for the conveyance of concentrated mineral acids has been developed by Dunlop Hose Division, Team Valley Trading Estate, Gateshead, under the trade name of Valithene.

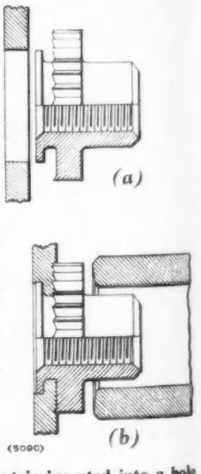
The hose, which has greater flexibility than steel or rigid polyethylene, is expected to have a number of uses, particularly in the chemical industry. Applications for which it is considered suitable include: temporary pipe lines; lead pipe replacement in chemical plant; chlorine water plant pipes; pipe lines for dye stuffs; pharmaceutical and fine organic chemical plant; and the conveyance of liquid foodstuffs, wines and spirits and of soap detergents.

Sizes in which the hose is available range from $\frac{1}{2}$ in to 3 in bore, and lengths of up to 60 ft can be supplied. Working temperatures should in general not exceed 60° C, although very low pressure steam may be used for cleansing, provided that the other end of the hose is open to the atmosphere. Maximum working pressure is 50 lb per sq. in.

SHEET METAL FIXING

Most sheet metal is too thin to take a tapped hole and various forms of insert have been developed to enable screws to hold. A recent one is the Rosan Press-Nut now being manufactured in this country by the Instrument Screw Company, Limited, Northolt Road, South Harrow, Middlesex. All threads up to $\frac{3}{8}$ in are available.

To fix the nut in the sheet metal, a hole is first drilled or punched to take the smaller flange. A hollow punch is then placed over the shank of the nut and struck once or twice. This causes the sheet material to flow into the groove behind the flange of the nut and grip it in place. The teeth of the large serrated flange imbed themselves into the material and prevent rotation.



(5090)

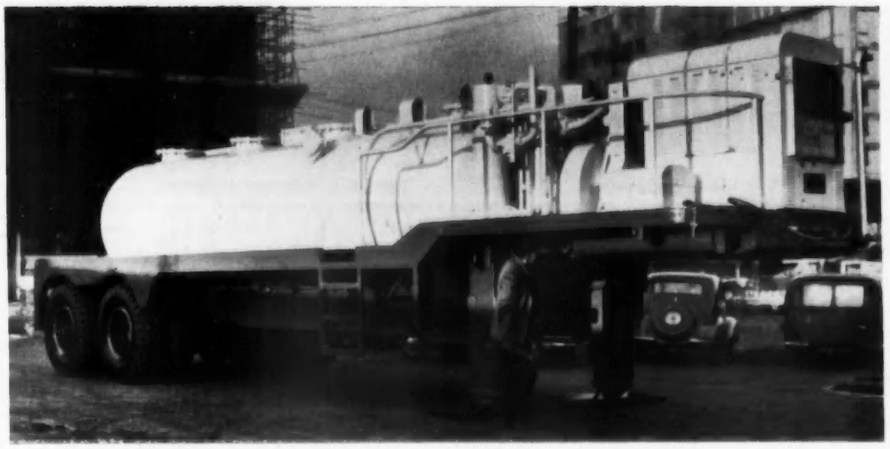
The flange of the press-nut is inserted into a hole in the sheet and a hollow punch placed over the shank. One or two blows cause the material to flow into the groove.

Continuing **Plant and Equipment**

TRANSPORTING OILWELL "MUD"

Two 4,500 gal mobile tanks made to the order of the Shell Petroleum Company, Limited, and shipped to Venezuela for use in the oilfields, are specially designed for transporting drilling fluid or "mud" which is used to keep the drill bit cool and to bring the cuttings to the surface. Each tank is 27 ft overall and 6 ft diameter, and is fitted with access catwalks and four inspection manholes at the top. The tanks were made by Bristowes Machinery Limited, of Edmonton, London, N.18, and are mounted on semi-trailers built by R. A. Dyson and Company, Limited, Grafton Street, Liverpool, 9. The trailers are designed for use with Scammell tractors, and to facilitate coupling and uncoupling they are fitted with extra heavy duty hydraulic lifting gear capable of raising and supporting the front end of the vehicle even when fully loaded. A full width landing pan enables the gear to be used on soft ground.

The trailer rear bogie is of the tandem axle pattern, the two axles being rubber mounted on solid pivoted walking beams. To give maximum flotation, twin 14·00 by 24/20-ply Dunlop Power Rib pneumatic tyres are fitted. 2.LS Girling internal expanding brakes, size 15½ in by 7 in, are fitted to all wheels. The brakes are actuated by a two-line air pressure system from the prime mover and there is also a mechanical hand parking control at the side of the semi-trailer.



Drilling "mud" is transported in the Venezuelan oilfields by this 4,500 gal semi-trailer tank, with pneumatic filling and discharge gear.

Filling of the tanks is by vacuum, and discharge is by compressed air, a reciprocating compressor, driven by a Perkins S6 diesel engine being mounted on the raised front deck of the semi-trailer. Air at 30 lb per sq. in is delivered either to the tank for discharging the contents, or to an ejector system which creates a vacuum within the tank and so draws up the mud into it without any risk of contaminating the compressor. An alternative method is by direct suction which gives a slightly greater vacuum. An automatic vacuum breaker operates when the tank is full.

VARIABLE SPEED MOTOR DRIVE

Two types of variable speed drive are now being marketed in this country by Electropower Gears Limited, Kingsbury Works, Kingsbury Road, London, N.W.9. One is mechanical in operation and the other is electronic.

The mechanical drive embodies the Brottby system developed in Sweden, the principle of which is illustrated in Fig. 1. The power is transmitted through hardened and ground rollers which roll against hardened and ground races in an oil bath. The pressure is dependent on the torque and therefore the full motor power can be transmitted at all speeds of the output shaft. Speed variations are obtained by means of the lever on the top of the box, as shown in Fig. 2, which swings the axis of the rollers so that their peripheries run at different radii on the races. The speed of the output shaft is indicated on a scale. With this form of transmission the efficiency is between 85 and 95 per cent. Models are now available in the power range from ¼ to 25 h.p.

The electronic system controls the speed of the motor itself and will maintain the speed constant to within 3 per cent of the set value from no-load to full load. When a tacho-generator is fitted, this can be improved to within ½ per cent. The controller is connected to the motor by four wires and can be remotely sited if desired. At present the standard range of power is from ⅛ to 3 h.p.

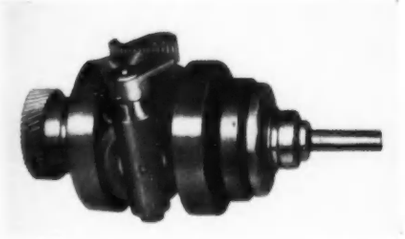


Fig. 1 Speed variation in the Brottby system is obtained by swinging the axes of the rollers.

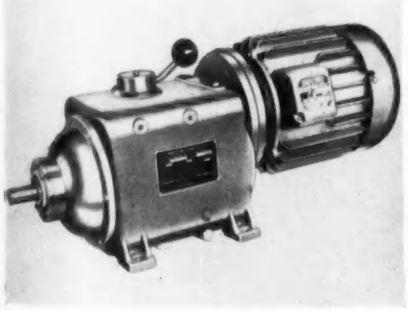


Fig. 2 Speed control is effected by the lever, which has an engraved scale of output shaft speed.

STEEL WITHOUT SMOKE

What is believed to be the first system using oil firing for the re-heating of slabs and "cheeses" prior to rolling into sheets is now in operation. It forms part of the conversion scheme carried out at the Aetna Works of Spear and Jackson Limited, Saville Street, Sheffield, 4, by which all the coal-fired furnaces in their rolling mill, forge and heat-treatment departments have been changed to oil or gas firing.

The latest installation gives a controlled heat input with a temperature range from 750° C to 1,300° C. The self-proportioning burners permit atmosphere control as well as temperature regulation and fuel economy. In addition exhaust gases from high-temperature chambers are used by passing them through a central low temperature chamber fitted with booster burners. Owing to its construction, the same furnace can be used for heat treatment purposes as well. Temperatures can now be measured on an auxiliary panel designed by the firm in conjunction with the furnace builders, Markham (Sheffield) Limited.

The change is expected to give cleaner slabs, free from scale, to effect economies in the use of fuel, and reduce atmospheric pollution.

HANDLING HEAVY PARTS FOR MACHINING

For handling heavy or awkward parts in the machine shop, Trucks and Pallets (Stackers), Limited, Gas Street, Birmingham, 1, have produced the TPS MachinLoder shown in the illustration. The standard model has a capacity of 500 lb at 12 in centres and other sizes are capable of dealing with loads of 750 and 1,000 lb.

The load can be lifted to a height of 4 ft 6 in from the floor either by a hand pump or by battery power. The standard fitting is a pair of 24 in forks but these can be replaced by a 20 in jib, squeeze clamps or a roller platform. Although designed primarily for machine loading, the truck can be used for pallet handling or any similar operation. Other models available have pedestrian control, battery electric lift or power drive.

The MachinLoder is designed for handling heavy parts in the machine shop.

Continuing **Plant and Equipment**

MECHANICAL HANDLING

1—*Torque Transmission* *Trucks and Loaders*

MATERIALS handling equipment of all varieties, and of several nationalities, is now on view to the public at Earls Court, London, where the Mechanical Handling Exhibition opened two days ago. The exhibition, which is organised by the journal *Mechanical Handling*, continues until 17 May; running concurrently at Earls Court is the Materials Handling Convention, at which specialised aspects of mechanical handling are being presented for discussion. The subjects for next week include mobile equipment for power stations (Monday), work study (Tuesday), warehouses (Wednesday), labour relations (Thursday), and mechanisation problems in the port of London (Friday). Each session commences at 11 a.m. Handling problems in the brewing industry are under consideration to-day, 9 May, and the motor industry's problems were dealt with yesterday.

The range of mechanical handling appliances available to British industry, and for export, is now very considerable, and we propose in this article to look briefly at a few exhibits typical of the modern trend.

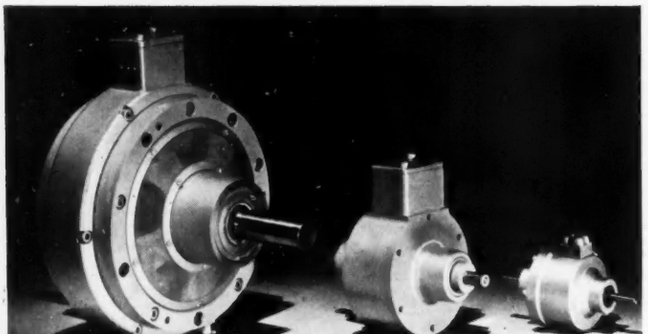


Fig. 1 Magnetic particle couplings of 50, 1, and ⅛ lb-ft capacity. S. Smith and Sons (England) Ltd..

Firstly, we should like to mention briefly a development in torque transmission which is likely to influence the future design of mechanical handling equipment such as trucks and tractors, and cranes—particularly in remote control applications. S. Smith and Sons (England) Limited, Witney, are showing their magnetic particle coupling for industrial drives (Fig. 1)—a constant-torque unit in torque capacities from ⅛ lb-ft to 50 lb-ft. We propose to describe this unit in greater detail in a forthcoming issue, confining this reference to the manufacturers' summary of its principal features: the torque is accurately controlled by the exciting current, and is independent of slip velocities; operation is smooth with no snatch or judder; there are no sliprings, and no mechanical engagement of moving parts, so wear is negligible and maintenance is reduced to the minimum; and the coupling can operate in either direction.

There is an increasing use of torque converter drives in industrial trucks and tractors. Among the manufacturers exhibiting such features are the Mercury Truck and Tractor Company Limited, Gloucester, showing a diesel-driven dual-purpose shunting and towing tractor fitted with Brockhouse torque converter; and Conveyancer Fork Trucks Limited, Warrington, who show a new 2 ton capacity "yard" truck (Fig. 2) specially designed for rugged outdoor operation and fitted with a torque converter drive.

The new Universal series of fork trucks introduced by Coventry Climax Engines Limited, Coventry, are available in capacities from 2,000 lb to 4,000 lb, with diesel, petrol, liquid petroleum gas, or electric power. Fig. 3 shows a 4,000 lb diesel truck at work. Petrol or diesel-driven trucks are offered with a choice of Brockhouse torque-converter drive or with a clutch/constant-mesh-gear drive. On all the mechanically driven trucks, the drive axle, steering axle, mast assembly and hydraulic equipment are interchangeable, and many of these main assemblies are interchangeable also with those of the electric trucks. One of the principal claims for the Universal trucks is their light weight coupled with excellent stability, resulting from a good weight distribution and low centre of gravity.

All the machines shown by Mathew Brothers, Wallington, incorporate torque converters, power shift transmission, power steering and four-wheel drive. Their exhibits include 6,000 lb and 8,000 lb fork lift trucks designed to combine good manoeuvrability with high operating speeds, stability and the ability to operate on soft ground; and a new four-wheel drive loading shovel, Mastiff, shown in Fig. 4. Mastiff is designed for the bulk handling of all kinds of material and is suitable both for site work and for work on hard surfaces. It has a tractive effort of 14,000 lb, and is fitted with a 1¼ cu yd bucket, and 14 in by 24 in Earth Mover tyres all round.

The new NR40 forklift truck (Fig. 5), shown by Ransomes, Sims and Jefferies, Limited, Ipswich, has a capacity of 4,000 lb at a load centre of 24 in, or 2 tons at 20 in, and is battery driven. It has a generous power/weight ratio. Special attention has been paid to the fork profile; all surplus metal has been discarded leaving a fork section with maximum strength at minimum weight. The NR40 is a sturdy and compact machine. The turning circle has been reduced to the minimum, so that right-angle stacking is possible in an aisle width of only 91 in plus the length of the load. An outstanding feature is its dual-speed motor. By altering the terminals at the back of the control panel the top speed, unladen, can be reduced from 5·5 m.p.h. to 4·5 m.p.h., and vice versa. This simple operation enables the truck to conserve its power without wastage when operating on varying floor conditions.

A diverter can be fitted as an optional extra to give a fifth speed, and in conjunction with the slow-speed motor connections this will give the most economical operation where the truck is

Fig. 2 Two-ton capacity yard truck. Conveyancer Fork Trucks Ltd.

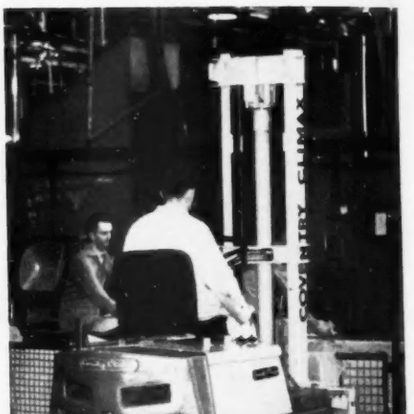


Fig. 3 4,000 lb diesel truck, Universal series. Coventry Climax Engines Ltd.

Fig. 4 Four-wheel drive Mastiff loading shovel, for the bulk handling of all kinds of materials. Mathew Brothers.

working in both open and confined conditions. A maximum lift height of 14 ft is available, at which height the carrying capacity remains unchanged.

The Muir-Hill model 4-WL tractor shovel (Fig. 6), exhibited by E. Boydell and Company Limited, Manchester, is a heavy-duty diesel-powered hydraulically-operated machine designed to give crawler tractor performance with the manoeuvrability of a rubber-tyred unit. This is achieved by four-wheel drive transmitted through large wheels at minimum centres, carrying a chassis and superstructure of great strength and rigidity. There is no articulation whatsoever in the suspension; steering is effected by clutches and brakes working on the opposing sides as with a tracked vehicle.

During an extensive period of exhaustive testing this machine has evinced remarkable qualities in performances on unmade ground, resulting largely from the form of construction and materially assisted by the provision of a six-speed gearbox, plus supplementary hub reduction gear, giving a choice of twelve forward speeds and four reverse, through the four-wheel drive system. Equipped as standard with a $\frac{3}{4}$ cu. yd full-width bucket and full-flow filtered hydraulic system with double-acting rams to both beam and bucket, automatic or driver-controlled "roll-back" action is afforded.

On view on the stand of C. H. Johnson (Machinery) Limited, Stockport, is an example of their new Johnson-Vilver industrial lifting platforms, designed to provide a simple and inexpensive method of elevating goods without extensive structural alterations. Four basic types are available, ranging from $1\frac{1}{2}$ ton to 15 ton capacity with lifting platforms varying in size from 5 ft by 3 ft 3 in to 26 ft 3 in by 7 ft 7 in. The largest version can carry a loaded lorry. The one on view at Earls Court is the smallest variant, the Cadet, which can be accommodated in positions inaccessible to other means of lifting, and which requires virtually no foundations.

(To be continued)

Fig. 5 (left). 4,000 lb fork-lift truck with dual speed motor. Ransomes, Sims and Jefferies, Ltd.

Fig. 6 (right). Heavy-duty tractor shovel. E. Boydell and Co. Ltd.

NOTICES OF MEETINGS

Aslib

MANCHESTER
Meeting of librarians and information officers interested in the study of classification to consider whether there is sufficient support in the north of England to justify the formation of a classification study group. Central Library, Manchester. Tues., 13 May, 7 p.m. (Further details available from Miss E. Boddy, The Retreat, Tideswell Lane, Eyam, near Sheffield.)

British Computer Society

LONDON
"Four Years of Automatic Office Work," by T. R. Thompson. Caxton Hall, off Victoria Street, Westminster, S.W.1. Mon., 19 May, 6.15 p.m.

British Institution of Radio Engineers

LONDON
"Cold-Cathode Voltage Transfer Circuits," by J. H. Beesley. London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1. Wed., 21 May, 6.30 p.m.*

Combustion Engineering Association

LONDON
"The High Duty Combustion Chamber," by R. P. Fraser, at 10.30 a.m. "Coke in Industry," by E. Murphy and A. S. Boyle, at 2.30 p.m. Southern Region. St. Ermin's Hotel, Caxton Street, Victoria, S.W.1. Tues., 13 May.

Incorporated Plant Engineers

BLACKBURN
Brains Trust Meeting. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., 15 May, 7.30 p.m.
BRISTOL
"History of Rolls-Royce," by C. W. Morton. Western Branch. Grand Hotel, Bristol. Wed., 14 May, 7.15 p.m.
CHESTER
"Heat Exchangers," by A. Faunbern. Mersey and North Wales Branch. The Blossoms, Chester. Mon., 12 May, 7.15 p.m.
MANCHESTER
"Selection of Machine Tools for Maintenance Departments," by R. G. Clowes. Manchester Branch. Tues., 13 May, 7.15 p.m.
ROCHESTER
"Maintenance of Shell Boilers," by J. N. Williams. Kent Branch. King's Head Hotel, High Street, Rochester. Wed., 21 May, 7 p.m.

Institution of Civil Engineers

LONDON
"Volta Bridge," by P. A. Scott and Gilbert Rogers. Tues., 13 May, 5.30 p.m.*
"Multi-Storey Construction in Concrete," by J. A. Derrington. Tues., 20 May, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"A New Cathode-Ray Tube for Monochrome and Colour Television," by Dr. Ing. D. Gabor, P. R. Stuart and P. G. Kalman. Radio and Telecommunication Section. Wed., 14 May, 5.30 p.m.*
Annual General Meeting of the Institution, followed, at 6.30 p.m., by "Recent Developments in Electronics in the United States," by D. G. Fink. Thurs., 15 May.
Annual General Meeting and Film Show. London Graduate and Student Section. Mon., 12 May, 6.30 p.m.*

Institution of Mining and Metallurgy

LONDON
Annual General Meeting (open only to corporate and non-corporate members of the Institution), at 4 p.m. Tea at 4.30 p.m. President Address on "Productivity," by J. B. Dennison, at 5.15 p.m. Geological Society, Burlington House, Piccadilly, W.1. Thurs., 15 May.

Institution of Production Engineers

BIRMINGHAM
"Product Design," by R. Cantor. Midlands Region. James Watt Memorial Institute, Great Charles Street, Birmingham. Tues., 13 May, 7 p.m.

Institution of Public Health Engineers

LONDON
"Discharge of Sewage and Industrial Wastes into Estuaries," by Dr. B. A. Southgate. Caxton Hall, off Victoria Street, S.W.1. Thurs., 15 May, 6 p.m.*

Junior Institution of Engineers

SHEFFIELD
Repetition of Presidential Address on "The Origin and Function of R.E.M.E.," by Major-General W. A. Lord. Sheffield Section. Royal Victoria Hotel, Sheffield. Fri., 16 May, 7.30 p.m.

Newcomen Society

LONDON
Third Dickinson Biennial Memorial Lecture on "Sixty Glorious Years: The Impact of Engineering on Society in the Reign of Queen Victoria," by Dr. S. B. Hamilton. Wed., 14 May, 6 p.m.

Royal Aeronautical Society

LONDON
46th Wilbur Wright Memorial Lecture: "Automatic Flight—The British Story," by G. W. H. Gardner. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Thurs., 15 May, 6 p.m.*

Royal Institution

LONDON
"The Royal Institution and the Teaching of Science in the Nineteenth Century," by Edward Ironmonger. Wed., 14 May, 9 p.m.

Royal Meteorological Society

LONDON
"Progress in Atmospheric Pollution Research," by C. J. Regan; "The Introduction of Smoke Control Areas," by Dr. W. C. Turner; "Climatological Aspects of Air Pollution," by R. G. Veryard; and "Radioactivity in the Atmosphere: Its Origin and Measurement," by N. G. Stewart. Joint Meeting with the National Society for Clean Air. Agricultural House, Knightsbridge, S.W.1. Tues., 13 May, 4.30 p.m.

Royal Society

LONDON
"The Institute of Aviation Medicine": a lecture by Group-Captain W. K. Stewart. Thurs., 29 May, 4.30 p.m.*

Royal Society of Arts

LONDON
Sir William Jackson Pope Memorial Lecture: "Expanding Horizons in Organic Chemistry," by Professor Sir Ian Heilbron. Wed., 14 May, 2.30 p.m.

Society of Instrument Technology

LONDON
Annual General Meeting and Presidential Address. Manson House, Portland Place, W.1. Tues., 20 May, 6 p.m.
NEWCASTLE UPON TYNE
Annual General Meeting. Newcastle Section. King's College, Stephenson Building, Newcastle upon Tyne. Wed., 21 May, 7 p.m.

South Wales Institute of Engineers

CARDIFF
"Staple Pit Bunkerage versus Other Types of Bunkerage," by G. Blackmore. Thurs., 15 May, 6 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
All-day conference on "Metallurgical and Engineering Aspects of Weight-Saving in Steel Structures." Fri., 16 May, 10 a.m. and 2.15 p.m.

Women's Engineering Society

LONDON
"Rubber as Applied to General Engineering," by S. W. Marsh. Electricity Council's Offices, Winsley Street, W.1. Tues., 20 May, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Aslib (Association of Special Libraries and Information Bureaux), 4 Palace Gate, London, W.8. (KNightsbridge 0444.)
British Computer Society, 29 Bury Street, St. James's, London, S.W.1.
British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. (MUSeum 1901.)
Combustion Engineering Association, 6 Duke Street, St. James's London, S.W.1. (WHItehall 5536.)
Incorporated Plant Engineers, 12 The Parade, Solihull Warwickshire. (Solihull 1111.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Mining and Metallurgy, 44 Portland Place, London, W.1. (LANgham 3802.)
Institution of Production Engineers, 10 Chesterfield Street, London, W.1. (GROsvenor 5254.)
Institution of Public Health Engineers, 118 Victoria Street, London, S.W.1. (VICtoria 3017.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1. (VICtoria 0786.)
Newcomen Society, Science Museum, Exhibition Road, London, S.W.7. (KENsington 1793.)
Royal Aeronautical Society, 4 Hamilton Place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle Street, London, W.1. (HYDe Park 0669.)
Royal Meteorological Society, 49 Cromwell Road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Society of Instrument Technology, 20 Queen Anne Street, London, W.1. (LANgham 4251.)
South Wales Institute of Engineers, Park Place, Cardiff. (Cardiff 23296.)
West of Scotland Iron and Steel Institute, 39 Elmbank Crescent, Glasgow, C.2. (Central 5181.)
Women's Engineering Society, 25 Foubert's Place, London, W.1. (GERrard 5212.)

Companies in the News

Old Name: New Look

The conflict between old name and new activities is common enough, particularly in engineering where diversification has gone farther than in most other industries. But few companies change their name—often with good reason. Many have generations of good-will attached to them, even affection, and any change would be a step in the dark. Chatwood-Milner Limited is such a company, formed from the amalgamation of the Chatwood Safe and Engineering Company and Milner Safe Company. They have a world-wide reputation as manufacturers of safes, strong-room doors, fire resisting equipment and are doubtless best known in their capacity as bankers' engineers. Yet they have many other products for other industries, such as special air lock and soundproof doors for the aircraft industry, wind tunnel sections and equipment, radiation shielding doors for nuclear plants, mechanical handling equipment for radio-active materials and other products.

They have factories at Shrewsbury and Speke and operate as a member company of the Hall Engineering Industries group, which includes Hall and Pickles and British Reinforced Concrete Engineering. Two of the companies in the group have recently changed their names—Auto Body Dies Limited were formerly known as Composite Forgings Limited, and Webslight Limited as Harry Heath (General Advertisers) Limited. As manufacturers of road signs and advertising signs the latter's original name could hardly have been more misleading. Chatwood-Milner have formed a new division, the Sound Insulation and Nuclear Protection Division, which will deal with the company's business for the aircraft and atomic energy industries.

Hall Engineering Industries have had a fairly good year in 1957. Turnover rose by £700,000 to £10·9 million, the only drawback being a fall in profits from £845,000 in 1956 to £759,000, mostly due said their chairman, Mr. E. N. Hall, "to increased labour costs and keener competition." The group's important stake in the manufacture of special steels and in products manufactured from them should ensure for them good long-term prospects. They spent £1½ million last year on plant replacement and reorganisation and are well equipped to meet changing conditions.

World Steel in Low Gear

The annual reports of three steel-making companies—one British, one American and the other German—all point to harder times for the steel-makers. Phoenix-Rheinrohr A.G. of Düsseldorf, who produce semi's, rolled products and tube, report a new peak in turnover and a strong order book, but point out that the German economy "has passed from the expansionist period of reconstruction to a phase of consolidation." The demand for rolled steel continued to be very strong inside Germany but there was "a slight setback" in export markets during the second half of the year. The market for tube was marked by considerable changes. In particular there was a drop in the demand for oil pipes (as is commented upon in a Weekly Survey Note this week), but a rise in the demand for high quality tubes of all kinds, reflecting "both general technical progress and the application of higher operating pressures and temperatures." Phoenix-Rheinrohr look forward to further expansion in the long-term, but the current year is unlikely to see as big an increase in their labour force as last year—of 3,165 to 30,549.

United States Steel Corporation had "a good year despite lower operating rates in the latter part," and, like Phoenix, produced more (33·7 million net tons) than in 1956, at a rate amounting to 85·2 per cent of capacity. Despite the declining demand in the second half of the year, the expenditure on new plant was 665 million dol at the year end, compared to 775 million dol at the end of 1956 and 515 million dol actually spent during 1957. The company's fundamental and applied research staff was increased by 150 people to 900 at their Monroeville, Pennsylvania, research centre. Of the future, chairman Roger M. Blough had little definite to say, except to express his confidence that "the basic economic progress of the nation is certain to continue." Nevertheless, the situation is most serious and the U.S. steel industry is currently working at less than half capacity (47·8 per cent during the first week in May).

Darwins Limited benefited greatly from capital investment in earlier years, in common with most of Britain's metal and engineering industries. The chairman, Mr. F. Thompson-Schwab found the prospects for the current year "more difficult to forecast than for several years" and pointed out that even a slight decline in output would affect the financial results "out of all proportion to the percentage of such reduction." For each of these three companies the boom is over: the differences are that for the Germans demand remains very high, for the British less so, with conditions in the home market more unsettled, and for the Americans the collapse has been complete and shattering.

BEA Flies High

In spite of abnormally high losses in the winter months, British European Airways earned a record net profit of over £1 million in the financial year ended 31 March 1958. This compares with a net profit of £216,770 in 1956/57 and was mainly due to the increased passenger traffic carried during the year. In fact, the rate of increase of passenger traffic in 1957/58 was higher than in the previous year and the Corporation expects to carry over 3 million passengers in the coming year and to operate over 1,000 million passenger miles in the year. Freight carried rose by 7·6 per cent in 1957/58 but this compares with a corresponding increase of 22·3 per cent over the previous year.

These results are in marked contrast to the estimated loss of £2¾ million by BOAC recently announced by the Minister of Transport and Civil Aviation and are a tribute to the popularity of the Viscount which is now in service on the majority of BEA routes. Indeed, BEA are in the altogether fortunate position of operating the most modern aircraft of all those in service with its competitors. It is expected that the Corporation's programme for an all-turbine fleet will be completed during the summer with the retirement of the remaining piston-engined Elizabethans. Two Elizabethans will, however, be used for engine development flying for the Rolls-Royce Tyne turbo-prop, the designated engine for the new Vanguard airliners which BEA have on order. The Vanguard is expected to enter service in 1960 and this should keep BEA well to the fore on middle-distance international routes, so laying a basis for profitable operation over the next few years.

Oil Giants' Outlook

The statements of Sir Neville Gass, chairman of the British Petroleum Company, and Lord Godber, chairman of the Shell Transport and Trading Company, contain comments of the greatest importance to plant manufacturers. Both tend to be more definite in their assessment of future trends than most chairmen of companies. Neither expect the present recession in world trade to last, nor the oil industry's expansion to come to a stop or even a significant slowdown. Sir Neville Gass makes plain that in matters of expansion, whether of production, refining, transportation or delivery, it is necessary to plan many years ahead. The momentum of expansion "cannot be immediately arrested at any given point, so that periods of imbalance are likely to occur if the tempo of increase is unexpectedly retarded."

Shell Transport and Trading appear to have been much more ruthless in their attitude to capital expenditure than B.P. When the time came early in 1957 to consider capital benefits for the year, the Suez crisis was at its height, and the Board decided to approve "only those new projects and operations as could not be postponed." When the crisis was resolved several of the plans were restored and the money expended, £386 million, was not very different from the figure for 1956. Of this £129 million was spent on production, £104 million on refineries and chemical plant and £6 million on sea-going fleets. The capital expenditure of the B.P. group was higher last year than in 1956—£100·5 million, compared to £86 million, including £38·5 million on refineries and £8·3 million on tankers.

Both companies have placed a high priority on the building of petroleum chemical plants. B.P. have associated themselves with chemical companies (British Hydrocarbon Chemicals in the United Kingdom, Naphtachimie in France and Farbenfabriken Bayer in Germany) in establishing petrochemical works at a total cost of some £50 million in the next four years. The expansion of Shell's interest in chemical production has been immense throughout the Western hemisphere, principally in the fields of solvents, industrial chemicals, plastics and resins, synthetic rubber, detergents and fertilisers. This is a field where considerable demand will arise for plant and machinery and one in which the expansion curve still points vigorously upwards. On the whole, therefore, the outlook of the two chairmen is encouraging: they have faith in the future and look upon the present as a temporary setback. They will continue to place orders for plant, but over the next two years this is likely to be on a substantially reduced scale.

Hard Work Ahead

The telecommunications equipment industry has had a remarkable year in 1957 and, despite the uncertain outlook of world trade which now prevails, should do almost as well during the current year. Ericsson Telephones Limited and Telegraph Construction and Maintenance Company Limited (Telcon) both reported a high level of production and satisfactory profits for last year's operations. Sir Harold Wernher, chairman of Ericsson, told his company's shareholders that sales profits were lower due to a heavy increase in labour costs. Considerable efforts have been made to expand production capacity and to modernise existing facilities. Expenditure in the past two years on new buildings and plant has amounted to £1·5 million and this made a substantial contribution to the higher output achieved during the year, despite the move of plant and machinery into new buildings. Orders at the beginning of the current year were good and steady progress was made in the further development of automatic telephones. Ericsson's obtained the first order to be placed in this country for an automatic Telex Service exchange.

Telcon reported a small increase in the value of output, but an increase of 26 per cent in trading profits. The increase in output was, in fact, much greater than the figures suggested, since the price of copper—which is a major component in most of their products—fell from £260 in January, 1957, to £180 a ton in December. Profits rose to £626,000. Their chairman, Sir John Dean, concluded that the company's performance in difficult conditions of fluctuating prices of materials and rising labour costs was "most satisfactory." He was reluctant to predict results during the current year, since Telcon's prosperity is "intimately interwoven with prospects overseas." The fear of the consequences of the United States recession and the fall in commodity prices led Sir John to foresee a more difficult time ahead: "One thing is certain," he said, "orders are more difficult to obtain and likely to be less profitable."

Book Reviews

SOCIAL SCIENCES APPLIED IN INDUSTRY

Some Applications of Behaviour Research. Edited by RENSIS LIKERT and SAMUEL P. HAYES, JNR. *United Nations Educational, Scientific and Cultural Organisation*, 19 *Avenue Kleber, Paris*, 16*e*. (16*s*.)

The social sciences have so far had a negligible impact on the conduct of human affairs in general and of industry in particular. This is so not only in terms of the customary unfair comparison with the impact of the natural sciences which are centuries ahead in their development, but even in relation to what the social sciences could already contribute.

Among the less obvious reasons for this lack of utilisation of knowledge is, paradoxically, the manner in which it is used by many of its protagonists. Industry knows of social research most often under the title of human relations, an ornamental adjunct to many a personnel department, without power and prestige, exercised apart from the daily urgencies of industrial organisation, and barely acknowledged in its existence by the top decision makers. Those who wish to change this state of affairs will find *Some Applications of Behaviour Research* stimulating reading on two levels: it contains an account of how top management in the United States became involved with principles and concepts of social research, and it is packed full with research results bearing on significant problems of human organisations.

The involvement of persons with power and prestige in industry and government was achieved through the establishment of the Foundation for Research on Human Behaviour, a body which owes its existence not to the charitable impulse of a millionaire but to the imaginative concern with research application of a group of social scientists in Ann Arbor, Mich. The Foundation, as one of its activities, runs seminars in which social scientists meet with business men to present research and to discuss its applicability to the specific problems which face the industrialists in the group.

The present volume is in fact a report of such seminar sessions. It provides some glimpses—one wishes there were more—into the manner in which various studies were used by the industrialists among the seminar participants and into the way research was received which demonstrated the shortcomings of some accepted industrial procedures. The impression is conveyed that the seminar discussion was invaluable in bridging the inevitable gap between the broad principles revealed by research and the concrete requirements presented by a specific industrial situation.

The major part of the volume is, however, devoted to the presentation of a fairly large number of studies dealing with such matters as forms of industrial leadership, morale and productivity (not necessarily positively correlated), the effects of training (sometimes short-lived and not always desirable), business forecasting (with some evidence of the degree of accuracy achieved through rigorous sampling methods) and the like. There is a particularly interesting chapter on group influences in marketing and public relations, with more emphasis than elsewhere on research methods, and a good introduction to the concept of reference groups. Each chapter has a useful anotated bibliography. There are many helpful diagrammatic presentations of research findings. The work of the Foundation for Research on Human Behaviour deserves emulation in this country.

NEW BOOKS

Rules Governing the Short-Circuit Testing of Air-Blast Circuit-Breakers for Alternating Current Systems. *The Association of Short-Circuit Testing Authorities Incorporated*, 36 *Kingsway, London, W.C.*2. (10*s*.)

These rules have been formulated to secure uniformity in tests until such time as a British Standard is published. Until then therefore certificates will be issued for the tests described here.

Kempe's Engineer's Year-Book for 1958: Volumes One and Two. Edited by C. E. PROCKTER and B. W. PENDRED. 63rd Edition. *Morgan Brothers Limited*, 28 *Essex Street, Strand, London, W.C.*2. (82*s*. 6*d*.)

"Kempe" is a standard work of reference to be found on almost every engineer's shelf. It is revised each year and this year some sections have been virtually re-written to bring them up to date. Many others have had material added.

Electronic Engineer's Reference Book. General Editor L. E. C. HUGHES, *Heywood and Company Limited, Ingersoll House*, 9 *Kingsway, W.C.*2. (84*s*.)

The applications of electronics have now grown so wide that the publishers of this reference work will have to consider issuing future editions in two volumes. The 1300 pages are divided into nine main headings covering such subjects as fundamentals; radiations; valves: computers and automatic controls. Radar and telecommunications are not included. The sections are written by acknowledged experts in the fields.

The BEAMA Catalogue. Fourth Edition. Published for the British Electrical and Allied Manufacturers' Association (Incorporated), by *Iliffe and Sons Limited, Dorset House, Stamford Street, London, S.E.*1. (120*s*.)

The publication of the fourth edition of the BEAMA catalogue has been made earlier than usual so that the volume should be available for the Brussels fair. In addition to the main volume, the three divisions, electrical power plant, electrical equipment in industry, and domestic appliances have been made separately available particularly for the fair. Not least useful among the contents is the five language glossary of the terms used in the buyers guide.

Electrical Conductors—International Standards Sizes. *British Insulated Callender's Cables Limited*, 21 *Bloomsbury Street, London, W.C.*1. (15*s*.)

This is believed to be the first standard reference work on electrical conductors. It contains, in tabular form, dimensions, materials and resistances of copper, alloy, and aluminium cables.

Engines for Small Power Craft. By P. N. BARNARD. *George Newnes Limited, Tower House, Southampton Street, Strand, London, W.C.*2. (16*s*.)

The book deals with engines below 60 h.p. and is directed mainly to the amateur or the small builder. Advice is given on selection, installation and operation of both petrol and diesel engines, and there is an index of makes arranged according to horse power.

Electricity Undertakings of the World 1957-58; The Electrical Journal Red Book. Sixty-Seventh Edition. *Benn Brothers Limited, Bouverie House*, 154 *Fleet Street, London, E.C.*4. (92*s*.)

The "Red Book" has long been one of the standard works of reference for the electricity industry. The 1958 volume follows the pattern of previous years and will doubtless prove as useful.

Chemical Reaction Engineering. 12th Meeting of the European Federation of Chemical Engineering, Amsterdam, 7, 8 and 9 May, 1957. *Symposium Publications Division, Pergamon Press Limited*, 4 *and* 5 *Fitzroy Square, London, S.W.*1. (80*s*.)

This, the first volume of an international series of monographs on chemical engineering, has been devoted to reprinting the 13 papers presented at a symposium, held in Amsterdam under the auspices of the European Federation of Chemical Engineering, and to the discussions to which they gave rise. Most of the papers are in English but one is in French and four are in German. All the papers, however, are preceded by an abstract in English, French and German. The volume constitutes a special supplement to the journal *Chemical Engineering Science*.

On the Shelf

By Frank H. Smith

The Institution of Engineers, Australia, have inserted one of those irritating loose leafs in their December *Journal*, but, this time, it is in a good cause. It is entitled "The Library of the Institution of Engineers, Australia," and, besides outlining its purpose ("The Library belongs to the members of the Institution . . .") and facilities, it also gives a list of the journals held.

Edward Arnold, 41 Maddox Street, London, W.1, issue a catalogue: "Scientific and Technical Publications Spring 1958," covering about 40 subjects. As usual, they put a vertical double line against new productions, which saves a lot of time when scanning. Blackwells, of Broad Street, Oxford, issue lists of new and forthcoming books on various subjects. Separate booklets give "Science and Mathematics," "Technical," "Electronics" and (lumped together) "Automation, Control Engineering and Computers." A difficulty that arose in my case is that somebody (who should have known better) rang me and asked if we had such and such a book published by Blackwells. These lists are, of course, books held by Blackwells as booksellers.

A short while ago I mentioned the plethora of publications of the American Society of Mechanical Engineers, and now I have received the "1958 listing" which comprises 20 pages full of publications at present obtainable.

UNESCO's *Monthly Bulletin on Scientific Documentation and Terminology* has an article on "superimposable, optical, peephole or coincidentally punched cards." From what I can gather, one does not poke a knitting needle through these. They work on a principle of "hold it up to the light—not a stain in sight."

Hilger and Watts Limited, 98 St. Pancras Way, London, N.W.1, have published Volume V (1952-53) of *Spectrochemical Abstracts*, compiled by E. H. S. van Someren and F. Lachman. A peculiar feature of this series is that the abstracts are numbered and the sequence is continued in successive volumes. This volume, in fact, covers Nos. 1690 to 1947, and these are divided between 12 headings, six of which are "substances analysed," others being apparatus, methods, source theory, reviews, charts and tables and, finally, book (which happens to be a report of an American Society for Testing Materials committee). The book starts with an author index (32 pages), then gives an index of elements observed as minor constituents of samples, and finally launches you on the abstracts.

Those interested in the contents and aims and objects of libraries may like to know of Project Note No. 19 of the Division of Building Research, National Research Council, Ottawa. This is a two and a half page circular giving particulars of the library service and details of its stock.

At the recent Aslib conference on translation, one speaker suggested that despite initial outlay, machine translation is eventually more economical than the employment of humans. Anybody interested in this might like to know of a new Butterworth (88 Kingsway, London, W.C.2) book on *Mechanical Resolution of Linguistic Problems*, by Booth, Brandwood and Cleave, at 50*s*.

The Academic Press's new journal, *Information and Control*, is dated September, 1957, for Volume I, part 1, and I make no apology for being over six months late in noticing it. I have only just seen it. The objects of the journal are to bring under one cover papers on various applications of theories of communication, computers and automatic control and to publish papers on such topics as: theory of communication; theory of automata; theory of automatic control systems; description and analysis of language and other natural information sources; communications and control systems which may include links within or between organisms; informational aspects of the theory of observation and measurement; and organisation, processing and retrieval of data.

Special Article

550 MW IS REACHED *Cross Compound Turbine*

It has now been announced that the contract for the first 550 MW turbo-generating set has been awarded to C. A. Parsons and Company Limited, Heaton Works, Newcastle upon Tyne. This follows the award of the contract for the boiler to International Combustion Limited, as was recorded in our issue of 28 February (page 287). It is intended to install two sets in the projected station at Thorpe Marsh near Doncaster. It is very necessary that the site should be within easy reach of a coalfield, for each set will consume between 205 and 220 tons of coal per hour, according to the quality.

In order to keep down the size of the generator, a system of water cooling for the stator windings has been adopted. A prototype 60 MW set has been undergoing tests in the Tilbury power station, having been commissioned in the early part of this year. It is only by the use of some form of direct cooling that sets as large as 300 MW can be kept within the limits imposed by road transport. Fig. 1 shows the extent to which it has been possible to increase output without corresponding increase in size.

The 550 MW set will be a cross compound unit consisting of two lines arranged in line ahead, each line comprising four turbines driving a 275 MW hydrogen and liquid cooled generator. Fig. 3 shows a photograph of a model of the complete machine, while Fig. 2 shows sections through the two lines.

All eight turbines are of the double flow type with the high-pressure cylinder on "A" line. From the exhaust of this cylinder the steam is reheated and passed to the first intermediate-pressure cylinder on " B " line.

On leaving this cylinder the steam divides equally between duplicate second intermediate-pressure cylinders, one on each line. Final expansion of the steam is then through two low-pressure cylinders on each line.

A single row velocity wheel is used in the initial stage of both the high-pressure turbine and the first intermediate-pressure turbine, the rest of the blading throughout the unit being of the reaction type. Both the high-pressure cylinder and the first intermediate-pressure cylinder are of the double shell design.

The machine will operate with steam at an initial pressure at the stop valves of 2,300 lb per sq. in and a temperature of 1,050° F. Reheating is to 1,050° F. Steam is led to the turbine through two steam chests arranged one on each side of the high-pressure cylinder. Each chest will be of forged construction containing two runaway stop valves and two governor valves.

Owing to the large storage capacity of the reheat system, it is necessary to prevent this steam flowing into the turbine when sudden loss of load occurs. For this purpose, intercept and reheat emergency stop valves are incorporated in the reheat system, and release valves which simultaneously release this steam to the atmosphere act as an additional safeguard.

The turbines will have two governors, the main speed control governor, driven from the high-pressure turbine shaft, and an auxiliary governor driven from the first intermediate-pressure turbine shaft. One governor is provided on each line of turbines and is mounted on a cross shaft driven through a worm and wheel.

Arrangements are made to extract steam from the turbine at seven pressure points in order to heat the condensate returning to the boiler to a temperature of 486° F.

To ensure uniform heating and cooling of the four turbine spindles and generator rotor on each line, when starting up or shutting down the machine, motor driven rolling gears are to be provided. With these gears the machine can be kept slowly turning after being shut down, so that distortion due to unequal temperature distribution is avoided.

The steam exhausting from the turbine's eight exhausts will be dealt with by four condensers having a total cooling surface of 330,000 sq. ft.

The generators will operate at 18,000 volts, 0·85 p.f., 50 cycles per second, at the design speed of 3,000 r.p.m. The rotors are to be of the gas cooled type operating in hydrogen at a pressure of 45 lb per sq. in. Each stator will have a direct cooled winding, using demineralised water as the cooling medium circulating

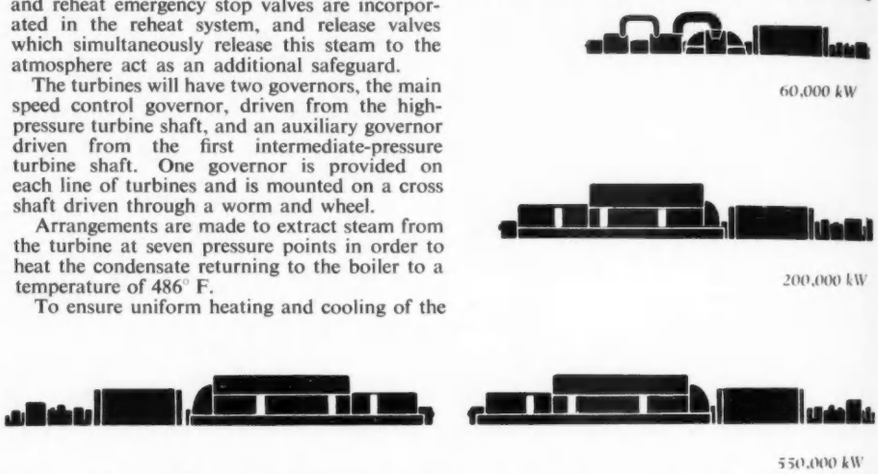


Fig. 1 More efficient methods of cooling have been the main factor in keeping down the size of generating sets.

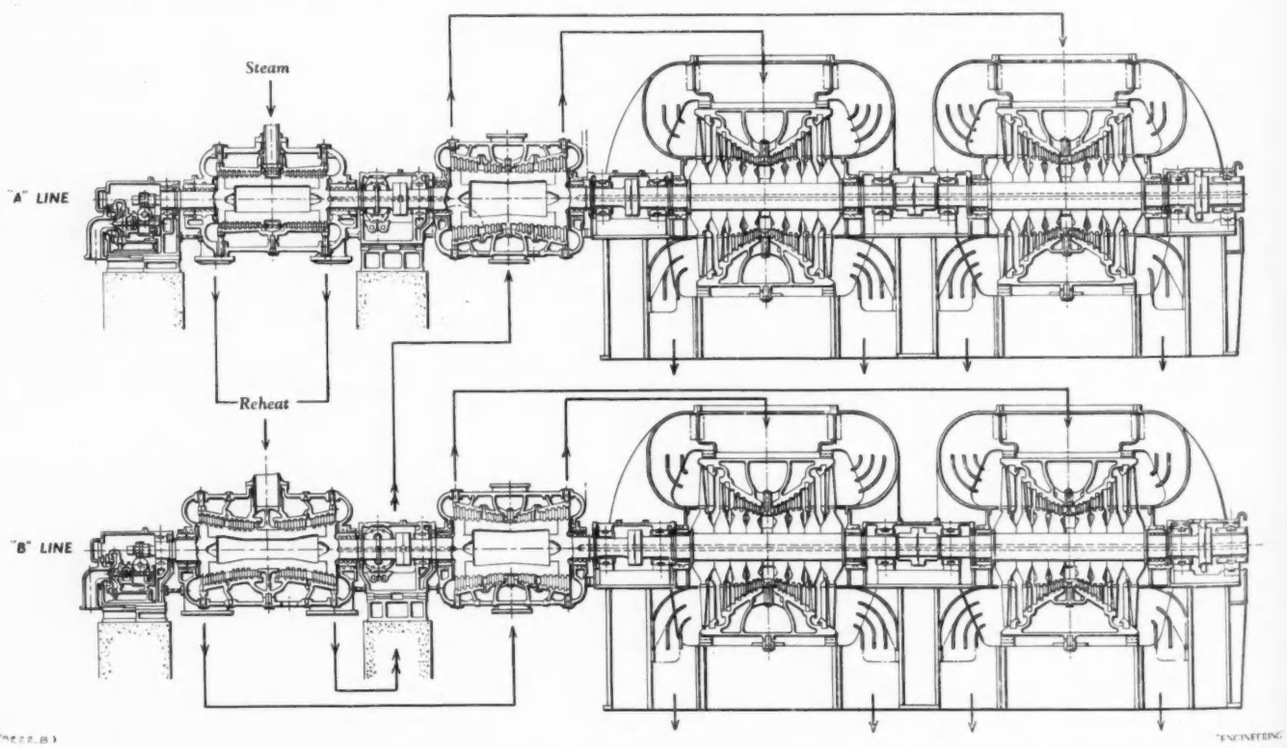


Fig. 2 Cross compounding is necessary in the 550 MW set in order to keep within transport limitations. The passage of the steam through the cylinders is shown diagrammatically.

through the conductors which are built up of hollow rectangular copper tubes.

Excitation for each generator is to be provided by a main and pilot exciter driven from the generator rotor shaft through reduction gearing. Ventilation of the exciters is effected by the circulation of air around a closed circuit by means of a blower mounted on the pinion of the gear drive to the main exciter shaft.

Unit construction (that is one boiler—one turbine), the practice now being followed by the CEGB, has afforded a big reduction in building costs as compared with stations erected soon after the war. It is interesting to recall that in their report for the year ended 31 March, 1957, the Central Electricity Authority quoted costs of £50 per kW—almost the same as in 1948 although the general level of costs has risen very considerably since then. The saving is due in part to the use of larger units and in part to the extended application of "skeleton" structures. Larger units occupy less volume per kW than do smaller ones and it is now possible to install boilers virtually in the open. Such a reduction in first cost is a very real challenge to the nuclear station, for the running costs of the two are not so very different.

As an example of how the size of a station falls with the size of unit installed, the projected station at Thorpe Marsh with two 550 MW sets will have a specific volume of about 12·6 cu. ft per kW while Skelton Grange "A", which contains six 60 MW sets fed from nine boilers, requires 28·6 cu. ft per kW. The smaller amount of steel and the reduction in building time that these figures represent account for the greatly reduced construction—and therefore capital—costs.

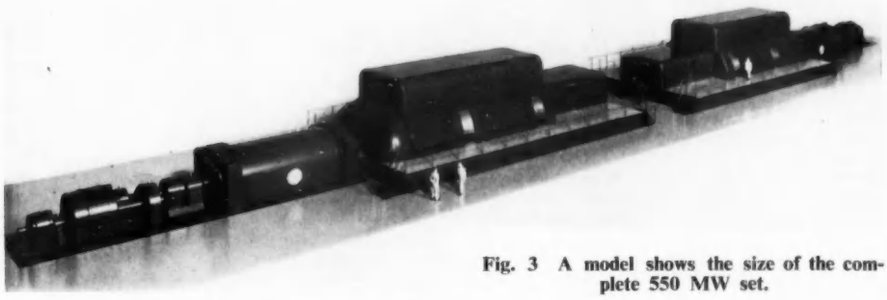


Fig. 3 A model shows the size of the complete 550 MW set.

The larger units also challenge the nuclear station on grounds of operating costs. A gain of 0·5 per cent in the average operating efficiency over all the sets in this country, represents a saving in coal of just over one million tons per annum. The most recent figures show that an overall improvement of 0·68 per cent was made during 1957/8, with the 20 most efficient stations (supplying 30 per cent of the total output) averaging 29·45 per cent. The best was again Castle Donington at 31·92 per cent, but the estimated figures for the English Electric 275 MW sets are 35 per cent; consequently as the newer, more efficient stations are brought into operation and the less efficient ones taken out, the overall figures will show a steady improvement. No figures have been given for the 550 MW sets: they will certainly not be less than 35 per cent.

Yet another feature that will keep operating costs down is the ability of the newer boilers to use poor coal. For example, the 550 MW International Combustion boilers are designed to take fuels with as much as 30 per cent ash and 20 per cent moisture, which must be verging on a slurry: yet the designed boiler efficiency is 90 per cent. When coal of this quality is being used, the cost per ton falls rapidly. Indeed a figure of 8*s*. per ton has been quoted for the slurry now being fired at the Barony station. When fuel costs in general reach this figure then indeed the nuclear stations will be hard put to it to produce electricity more cheaply than conventional steam stations.

Metals and Materials

FIFTY YEARS OF METALLURGICAL SCIENCE

In 1908 the methods for studying metals consisted mainly of the microscope, chemical analysis, mechanical testing, dilatation measurements, and thermal analysis. Resistivity measurements were only just coming in. The techniques of 50 years ago enabled metallurgists to be sure that alloys were of the compositions they had planned, that they possessed appropriate mechanical properties and that their microstructures were of the kind associated with good service. There was no clear understanding, however, of the manner in which neighbouring phases in alloy systems differed, nor of the changes that occurred within them.

This situation, Professor A. G. Quarrell, of the University of Sheffield, in his 48th annual May Lecture of the Institute of Metals, delivered at the Golden Jubilee Spring Meeting of the Institute held in London on 29 April, stated had been changed as the result of a suggestion, made in 1912 by M. von Laue, that X-rays should be of the right wavelength to be diffracted by the regular arrangement of atoms within crystals. The first successful demonstration of X-ray diffraction and the pioneer work of W. H. and W. L. Bragg had soon followed, and from it had grown the tremendously powerful technique for studying atomic arrangements in crystalline substances that was now at the disposal of the research worker.

Instead of thinking of metals on a macro or microscopic scale, the metallurgist now thought of their atomic structure, and, increasingly, in terms of crystal lattices. At first these lattices had been regarded as perfect, with atoms occupying every site on the space lattice, but it was later realised that some phenomena could be explained only if the lattices were imperfect. With the idea of imperfections, such as vacancies and dislocations, had come some of the more spectacular achievements of modern physical metallurgy.

X-ray diffraction had revealed that each intermediate phase in alloy systems had a characteristic structure and that phases having similar properties frequently possessed the same type of crystalline structure. Some of the phases seemed to be based on simple chemical formulae, such as AgMg, Au_3Al, or Cu_9Al_4, but they did not obey the ordinary rules of chemical valency. The realisation that compound formation in alloy systems was of a type different from that encountered in ordinary inorganic and organic chemistry and that it was governed by different laws, had been due to Dr. W. Hume-Rothery. He had shown the existence of some order where previously none was visible, and he formulated a number of rules that seemed to govern certain aspects of alloy formation, at least in the less-complex systems.

The ultimate aim of metallurgists must be to know so much regarding the scientific principles governing alloy formation and the behaviour of alloys under service conditions that they were able to design alloys having the required combination of properties. It must be confessed, however, that they were far from being able to do this. Alloy theory could provide a satisfactory explanation of the constitution of some binary alloys, but it failed with others and with practically all the more complex alloys.

Nevertheless, tremendous advances had taken place in metallurgy: from the macroscopic to the microscopic, from the microscopic to the atomic—each of these steps had opened up new fields. The major developments associated with the appreciation of the atomic scale had probably already been realised. The next big step forward was likely to come with a proper understanding of the electronic structure of metals. Then, indeed, metallurgists might hope to be able to design alloys having specified properties.

CO-ORDINATION OF RESEARCH INTO DEEP DRAWING

The assessment of the suitability of sheet metal for deep drawing and related processes has been investigated for a number of years by many organisations in several countries. Largely owing to the lack of effective contact between the various investigators, however, much of the research effort expended appears to have been duplicated, and one result has been that a variety of testing equipment has been rendered available without clear or reliable indications of the relative merits of the various testing methods. In order to correct this situation an International Deep Drawing Research Group was formed last year by representatives from several European countries with the object of exchanging information and co-ordinating further research.

While valuable work has been done in the past in Great Britain, it has been felt increasingly that it should now be more broadly based and extended to cover the interests of all those concerned with the testing and deep drawing of metals. As a result of discussions between the British Iron and Steel Research Association, the British Non-Ferrous Metals Research Association, the Institute of Sheet Metal Engineering and the Production Engineering Research Association, a British Deep Drawing Research Group has been established.

The principal function of the committee of the new Group is to provide a focus for British research and to effect liaison with similar bodies in other countries through the International Deep Drawing Research Group. A second function is to encourage the initiation and the continuation of fundamental research and, in particular, to instigate and supervise a programme of co-operative investigations into the use of the cup-forming test, proposed by Professor H. W. Swift and performed according to the International Group's procedure. The chairman of the committee of the British Deep Drawing Research Group is Mr. G. Murray of the Pressed Steel Company Limited. The honorary secretary is Mr. John Hooper, of the Institute of Sheet Metal Engineering, John Adam House, Adelphi, London, W.C.2.

Marketing

A FOREIGN INVESTMENT POLICY

Americans are being advised to plan their investments abroad before they have to by necessity. Speaking before the Economic Club of Detroit recently, Mr. Loring K. Macy, director of the Bureau of Foreign Commerce, explained how most initial investments made abroad were largely fortuitous. In the case of a large manufacturer, a plant was set up in Europe "because the President liked to travel." Rarely, said Mr. Macy, did foreign investments result from a clearly stated policy, a carefully planned organisation or sound research. He went on to advocate these things, and to review the various parts of the world in which Americans could invest with advantage. Among his suggestions was the European common market. The creation of the common market, with the likelihood in four years' time that common tariff walls would be erected against the outside world, appeared good cause to invest now in companies needing capital to take full advantage of the wider market for their products.

Mr. Macy was advising his compatriots to look for opportunities to invest as an insurance against suddenly finding themselves excluded from large areas of the world. The same arguments could be put to British manufacturers, though it is hardly likely that a British Government official would care to do so. Many people who have thought about trade with Europe realise that the free trade area could be delayed long enough to produce the tariff barrier against British exports which Mr. Macy fears for United States industry. A good many firms, particularly in France and Italy, where there is a serious shortage of capital, are nervous of the prospects of free trade even within the limited area of the common market, because they doubt their own ability to withstand competition from Germany. British companies in particular can find there competitors who would welcome British support in the form of investment. It is possible, therefore, to buy control or a large interest in firms within the common market area as an insurance against the failure of the free trade area.

There is just enough time available, and endless opportunities, to become what Mr. Macy calls "on equal competitive footing with common market producers." If the free trade area should subsequently develop it would be a relatively simple task to concentrate production in Britain or elsewhere, taking advantage of the most favourable conditions for supplying the area. There is little doubt that differences in transport, costs, labour rates, availability of materials, etc., will play a part in determining the location of industry in Western Europe. It follows therefore that those who can get a footing across the channel will tend to be in a better position to plan their activities and determine the pattern on which they should develop. Also—as many British manufacturers have already found out—it is not easy to absorb the knowledge and experience needed to succeed in Europe from outside.

Meanwhile, as Mr. Macy told his Detroit audience, there is need for "careful research, on a continuing basis, to keep the management of your company well-informed on situations which are developing abroad and which can be the basis of sound decisions." Such knowledge would appear to be the only practical answer to the possible threat of Continental insularity and a good basis for rapid expansion during the next ten to fifteen years. The company with factories astride the continent of Europe is much more likely to succeed than one looking on from the United States or even Britain.

More Price Cuts

The reduction in steel and aluminium prices last month has been followed by several others widely spread over the whole field of engineering and metals. Crompton Parkinson Limited have now announced "the latest phase" of their policy to bring prices down. From 1 May new prices, on average 8 per cent lower, came into force for industrial a.c. electric motors of the totally enclosed fan-cooled type. These motors, with outputs up to 20 h.p., are built to B.S. 2083 and form a large proportion of industrial machine drives. Annual sales on the British market are estimated at over 250,000 motors a year with a total value of £10 million.

There have now been substantial reductions in the prices of a wide range of electrical machinery. Two months ago C. P. made similar reductions in the prices of industrial a.c. ventilated motors up to 40 h.p. They say that these reductions came from a combination of factors resulting in higher production efficiency.

Art in Advertising

A series of most striking and warmly human paintings of eminent men in the setting of their work has been published by the British Aluminium Company Limited under the title "Portrait of an Age." The paintings are by Hans Erni, the eminent Swiss painter and graphic artist. This work has given Erni full scope for the expression of his great interest in the sciences and his deep feeling for human beings. The result is a set of portraits unique in 20 years of British advertising.

The caption to each of the six paintings is a skilfully worded expression of the man's technical problems and attention is discreetly drawn to aluminium, or the lack of it in Leonardo da Vinci's case, wherever appropriate. Hans Erni successfully captures the intellectual genius, humanity, and humility of Einstein; the imperious authority and transcendental powers of Toscanini; the explorative, serene vigilance of Marconi; the dedicated, kindly air of Rutherford; the modesty and devotion of Fleming at work on penicillin moulds. Da Vinci is shown as a sage and seer, building models of airplanes the shape of birds, with the caption—"lived in an age four centuries in advance of the materials needed to exploit his inventive genius to the full."

The production of the "Portrait of an Age" series by Charles Rosner & Associates, is of a high standard and the general effect most impressive.

Favourable Export Outlook

The latest review of British exports prospects shows that they remain good in a wide range of markets. The April issue of the *G.E.C. Export Guide* considers that demand is likely to continue at a high level in 16 countries and that it is improving in six, including Finland, Sweden and Spain. The major change in the first quarter of the year has been brought about by the United States slump and the consequent fall in commodity prices, which has affected the ability of some of our best customers to maintain their imports. It is unlikely, say G.E.C., that exports to the United States will go on increasing during the current quarter. Conditions in the markets most dependent on foodstuffs for their foreign income—for example, Australia, Denmark, the Irish Republic and the Netherlands—are deteriorating. In New Zealand (see next note) they are already bad.

The guide observes that the development of British exports over the past 20 years has been based too much on the Commonwealth and too little on Western Europe—"one of the most rapidly expanding markets in the world." So long as the United States economy fluctuates, as it has done twice in a major way since the war, Commonwealth countries must remain vulnerable and must protect themselves by introducing restrictions on their imports. The importance of finding a formula to associate Britain with the latest developments in Western Europe is reiterated in the strongest terms.

Angry New Zealanders

A bitter note has crept in the negotiations between Mr. Skinner, the Deputy Prime Minister of New Zealand and Sir David Eccles, President of the Board of Trade. The New Zealand Government are already most upset that no action on what they call the "butter dumping" should have yet been taken. This is now a major political issue in New Zealand and in the words of the Prime Minister, Mr. Nash, "a threat striking at the very roots of our economy."

The balance of payments crisis in New Zealand is something which vitally concerns Britain. Political as well as economic factors come into play. Nonetheless the action asked of Sir David, that he should slap on a duty on butter from Western Europe, would most certainly affect the attitude of the free trade area countries. It would also be out of keeping with all we have said about liberalising trade and doubtless be labelled as "typical British *volte-face*."

There are two solutions. The first is to stop "dumping," if it is in fact dumping, through normal international channels. The other is to provide New Zealand with the capital she requires to build up her industries and modernise her agriculture. Nothing else makes much sense.

Four Rings in America

Perkins have performed yet another spectacular commercial feat in getting the Chrysler Corporation of America to adopt two of their engines, the P6 and the R6, as alternative equipment. They will be offered for the latest United States built Dodge, De Soto and Fargo trucks.

Chrysler point out in their Dodge sales leaflets that the use of diesel engines ensures a saving of "more than 20 per cent in fuel consumption over gas-powered engines" and appear to be prepared to promote the sales of these engines. This move on the part of Chrysler is clearly the forerunner of others, particularly from distributors who could sell diesel engines—imported at highly competitive prices—for conversions of petrol-powered trucks and tractors. It is conceivable that some Americans could be persuaded to install them in their cars.

Clearly, for some time now, Perkins have been playing for very high stakes in America with all their characteristic drive and enthusiasm. It looks now as if the cards are loaded in their favour.

Chinese Interest in Railway Equipment

Four Chinese railway engineers, who were members of the technical mission which was recently in France to study the French Railways, will shortly visit this country to renew the long-standing acquaintance of Chinese railways with the British locomotive industry. They have accepted a joint invitation from the British Transport Commission and the Locomotive and Allied Manufacturers' Association. The visit will be a brief one, and a very crowded itinerary has already been arranged, concentrated on a.c. electrification.

LAMA point out in their announcement that the British locomotive industry has a long tradition of supplying the requirements of the Chinese railways and express the hope that this visit will prove to be "the forerunner of the renewal of this supply relationship between the United Kingdom and China as regards locomotives and railway equipment generally." It could also be the forerunner of similar visits by Chinese engineers to other sectors of the engineering industry, such as steel and chemical plant, electric generating equipment, machine tools and instrumentation.

Atomic Review

New Research Facilities

RESEARCH in nuclear energy is a costly business. Some indication as to how much it does cost was given by Sir Edwin Plowden, chairman of the U.K. Atomic Energy Authority, in the opening paper at the recent FBI Conference on Nuclear Energy at Eastbourne (ENGRG., 25 April, 1958, pp. 525-7). Yet the importance of providing research facilities for this work, whatever the cost, is recognised by authorities in many countries. Not only are they a prerequisite to the development of nuclear power plant and associated research problems, but such facilities are essential for the training of scientists and technologists in this type of work, and for providing the radioactive isotopes which are finding extensive application in industry, agriculture and medicine.

Last week we described the official opening of Australia's research establishment at Lucas Heights and the commissioning of its research reactor Hifar. Further details of the research facilities at Lucas Heights, and of some other facilities now available in Sweden and the United States, are now provided.

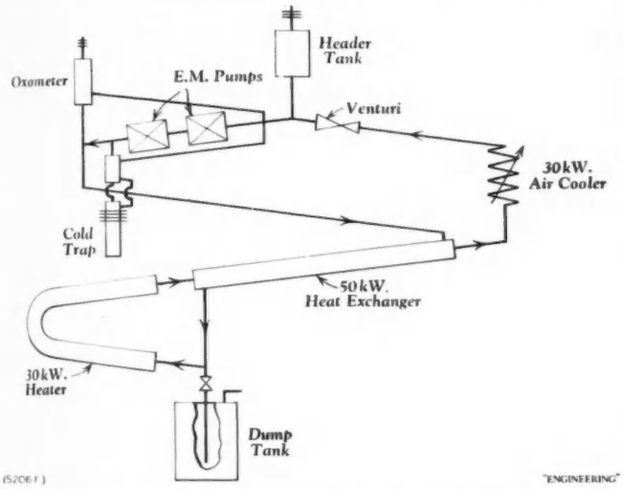


Fig. 1 (left) Main items and general outline of the sodium loop which is being built at Lucas Heights for liquid-metal-fuelled reactors research.

LMFR Research—Sodium Loop Facility

Details of the sodium loop facility which is nearing completion at the Australian Atomic Energy Commission Research Establishment, Lucas Heights, and which will be used for research work related to the development of a liquid-metal-fuelled reactor, have recently been given by Mr. C. L. W. Berglin, head of the chemical engineering section, (*Atomic Energy*, vol. 1, No. 2, p. 24, March 1958).

A diagram showing the main items of this loop is shown in Fig. 1. It will be used primarily for the training of recruited personnel in the handling of sodium, the calibration and testing of flow meters and pressure indicating devices, and for investigating the flow characteristics of suspensions of fissile material in sodium. A conventional figure-of-eight circuit, it is designed to circulate liquid sodium, at temperatures up to 500° C, at a rate of 10 gal per min. To maintain sufficient temperature differential around the loop, a 50 kW concentric tube heat exchanger is used, with heat input from a 30 kW heater and extraction by 30 kW air cooler. All parts of the loop in contact with sodium are fabricated in stabilised 18/8/1 stainless steel to B.S. Code 1500:1949 (Class I), welding where necessary by the argon gas-shielded tungsten arc process. The instrumentation includes venturi coupled to a differential pressure transmitter, electro-magnetic flow meters with associated millivolt recorders, pressure gauges, temperature indicators and recorders, and pulse units for the detection of sodium levels in the dump and header tanks. Flexible heating elements are used to keep parts of the circuit above 100° C, thus preventing freezing of the sodium.

The loop is housed in a galvanised iron sheet enclosure in order to confine the spraying of sodium should a leak occur. In case of fire, soda-ash or a proprietary powder will be used to contain the molten sodium and prevent access of air. Valves used in the loop are of the bellows seal type and are made up of annular discs of stainless steel, edge-welded at the inner and outer peripheries, to give a high active stroke-to-bellows length ratio.

The sodium is circulated in a pressurised nitrogen atmosphere, pressure being maintained sufficiently high to ensure that cavitation does not occur in the electro-magnetic pumps. The complete loop will be lagged with slag wool suitably encased and easily removed for access to the loop.

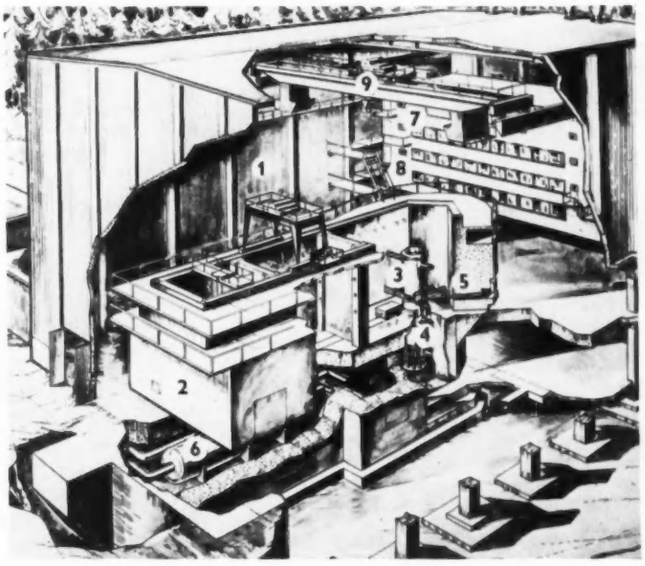


Fig. 2 (right) Sweden's atomic research station at Studsvik. Building 40 m by 30 m by 25 m high.

1. Reactor hall.
2. Reactor pool.
3. Reactor tank.
4. Fuel core.
5. Testing channel.
6. Moderator circuit.
7. Control room.
8. Work rooms.
9. Traversing gear.

An oxometer and cold trap are incorporated in the loop to ensure that oxygen concentration is kept lower than 20 p.p.m., which is the acceptable limit in order to keep mass transfer of metal down to an acceptable rate. The loop has been designed and made to high specification standards bearing in mind that this would be required of similar loops intended for irradiation tests in the research reactor.

Swedish Atomic Research Station

Work on Sweden's new atomic research station at Studsvik, on the Baltic coast south of Stockholm, is proceeding rapidly. The station, the layout of which is illustrated in Fig. 2, covers an area of some 300 acres; it will include a materials-testing reactor (R 2), a zero-energy reactor (R 0), a metallurgical laboratory, a pilot plant for plutonium extraction with research laboratory, and also a 5 MeV van de Graaf generator.

So far, most of the development work performed by AB Atomenergi, Sweden's mixed Government-private atomic energy company, has been carried out in the R 1 experimental low-energy pile (fuelled with uranium and moderated with heavy water) which was put into service at Stockholm during the summer of 1954. It is located underground in the capital's " City of Science " near the Stockholm Institute of Technology.

The R 2 reactor is now being installed at Studsvik and has been purchased from an American company, ACF Industries, Inc. It is scheduled to become critical at the turn of the year. The reactor is a modified pool type using enriched uranium with demineralised ordinary water as moderator and coolant, and is designed for a thermal capacity of 30,000 kW. It will primarily be used for developing reactor fuels but also for nuclear-physical research and isotope production. Total costs, including the building, 40 metres long, 30 metres wide and 25 metres high, which houses the unit, plus auxiliary equipment, are estimated at about Kr. 25,000,000 (£1,700,000).

The zero-energy reactor R 0, which is being designed by Atomenergi, is scheduled to come into operation this autumn. It will be fuelled with natural uranium and moderated with heavy water and has an output not exceeding 10 kW. Mainly intended for reactor-physical calculations, one of its first functions will be to investigate fuel elements for Sweden's planned power-producing atomic plant " Eve." The R 0 unit will be supplemented with a 5 MeV van de Graaf generator, which has been ordered from the United States and is expected to be delivered in about two years.

The projected laboratory for active metallurgy is in the first place intended for the study of fuel elements and construction materials that have been exposed to neutron radiation in the R 2 reactor. To protect the staff from radiation, the radioactive materials will be manipulated in cells with concrete walls of a thickness of 106 cm (42 in) and with inspection windows of special glass. There is also a special ventilation system to prevent the dispersion of airborne radioactivity.

The research station at Studsvik is also planned to include a pilot plant for treatment of burned-out fuel elements with particular view to utilising their plutonium content. It is intended to subject the elements to a chemical procedure by means of which uranium, plutonium and fission products are separated. Most of the highly radioactive fission products are to be stored in tanks in a rock chamber adjacent to the plutonium factory.

This plant is planned to take care of the fuels from the R 3 combined heating and power plant now under construction at Ågesta outside Stockholm, but it will also be dimensioned for

Continuing Atomic Review

processing fuels from the R 4-Eve power plant and from the Adam heating plant at Västerås.

Oak Ridge Reactor (ORR) Critical

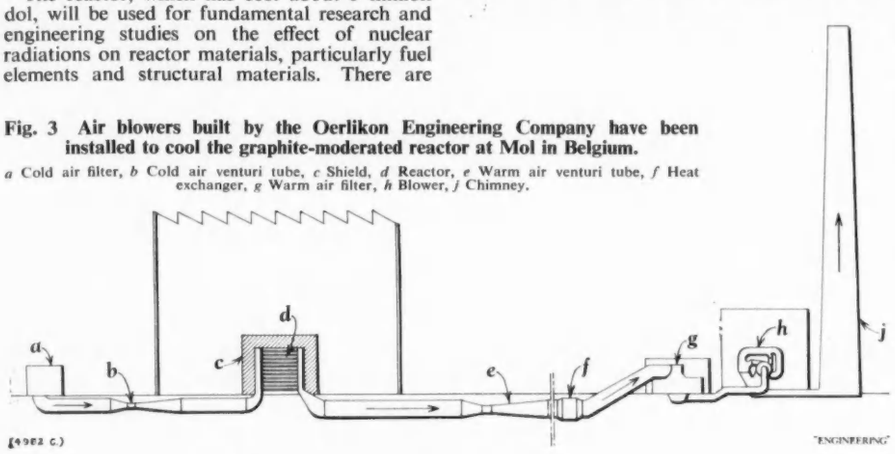
The high flux heterogeneous research reactor at Oak Ridge National Laboratory is now in operation. It is a tank type reactor, moderated and cooled with demineralised water and is designed to operate at a power level of 20 to 30 MW (thermal) with an average flux greater than 10^{14} n/cm²-sec. It has a beryllium-reflected core and uses enriched uranium fuel elements of uranium-aluminium alloy clad with aluminium.

The reactor core is housed in a tank 15 ft high and 5 ft in dia. which is submerged in a pool 21 ft long, 10 ft wide, and 28 ft deep. Access to the core is through penetrations in the concrete walls at one end and the sides, as well as from the top of the reactor and from an adjacent pool. Control is by four or more vertical rods which are actuated from below the reactor.

The reactor, which has cost about 5 million dol, will be used for fundamental research and engineering studies on the effect of nuclear radiations on reactor materials, particularly fuel elements and structural materials. There are now six nuclear reactors in operation at Oak Ridge.

Fig. 3 Air blowers built by the Oerlikon Engineering Company have been installed to cool the graphite-moderated reactor at Mol in Belgium.

a Cold air filter, *b* Cold air venturi tube, *c* Shield, *d* Reactor, *e* Warm air venturi tube, *f* Heat exchanger, *g* Warm air filter, *h* Blower, *j* Chimney.



General Electric Testing Reactor (NTR), California

Permission has been granted by the U.S. Atomic Energy Commission for the General Electric Company to commence the construction of the 30 MW (thermal) pressurised water reactor at the company's Vallecitos Atomic Laboratory in Alameda County, California. The reactor will provide high neutron flux experimental facilities for use in fuel element development and environmental testing. The Commission will provide the highly enriched uranium, containing 93 per cent U235, for use as reactor fuel.

MIT Research Reactor

Construction of this heavy water cooled and moderated research reactor which was authorised by the U.S. Atomic Energy Commission, 7 May 1956, has now been completed, and an application has been made to the Commission for an operating licence.

The reactor has been built by ACF Industries of New York and is generally similar to the CP-5 (Chicago Pile 5) reactor which has been in use at the Argonne National Laboratory, Lemont, Illinois, since 1953. It is enclosed in a gas-tight steel shell, 74 ft in dia. and 50 ft high, which is anchored to a 3½ ft concrete pad. Using enriched uranium as fuel, the reactor will operate at power levels up to 1 MW (heat) and will be used in medical therapy, and research and development work.

United States Fuels Technology Centre

The Argonne National Laboratory, which is operated by the University of Chicago under contract to the United States Atomic Energy Commission, is to have special facilities provided for developing techniques associated with the handling and fabrication of plutonium for use as a fuel in nuclear power reactors.

Since the original wartime work, plutonium studies on a laboratory scale have been made in the scattered facilities of the Argonne metallurgy division under the direction of Dr. Frank G. Foote. It is now necessary to expand the facilities to permit the development of production-scale processes. The new fuels technology centre will also be equipped with modern metallurgical facilities for studies on many other metals such as uranium and thorium—of interest in nuclear power reactor development. The installations will include small vacuum and resistance furnaces, moderately large foundry and fabrication shops with rolling mills, extrusion presses, welding equipment as well as machine shops.

In designing the new centre account had to be taken of the radioactive and toxic properties of plutonium which create a health hazard and necessitating special facilities to ensure safe handling. This added to the cost of the project which is expected to be about 10 million dol.

As at present planned the building will be in the west area of the Laboratory site, near Lemont, Illinois. It will have a reinforced concrete structural frame, with exterior walls consisting of face brick with concrete block backup. The building will have a gross area of about 220,000 ft and will include one- and two-storey space, high bay areas and the necessary special equipment space. The preliminary design study was made by Singmaster and Breyer, New York City.

The plutonium research at Argonne is complementary to work at Los Alamos where the fast neutron research reactor Clementine demonstrated the feasibility of plutonium as a nuclear fuel. Argonne scientists are now developing a breeder-type reactor EBR-2 which is expected to have a thermal output of 62,500 kW and a net electrical output of 17,500 kW. At first a U235 alloy core will be used but the reactor will be designed to allow a plutonium alloy core to be substituted later.

Reactor Cooling

A graphite-moderated reactor using natural uranium as fuel has been installed for research purposes at the Centre d'Etudes pour les Applications de l'Energie Nucleaire (CEAN) at Mol, Belgium; and as it is not intended for power generation air blowers have been supplied by the Oerlikon Engineering Company to carry away the heat produced.

The general arrangement of the plant is shown in the accompanying Fig. 3, from which it will be seen that cold air is drawn in through the filter *a* and passes through the venturi tube *b* to the reactor *d*. It is then exhausted through a second venturi tube *e* to the heat exchanger *f* and a filter *g* by the blower *h* and discharged to the chimney *i*. The pressure in the cooling system as far as the blower inlet is below that of the atmosphere to prevent the escape of radioactive air and the filters are used to remove radioactive particles. The venturi tubes serve the dual purpose of measuring the quantity of air passing through the reactor and of detecting any leakage of air into the system.

The maximum quantity of air required for cooling is 100 kg per second, to supply which four blowers have been installed, one normally acting as stand-by. Each set consists of two single stage units which are connected in parallel and are driven at a speed of 2,970 r.p.m. by a 950 kW, 3,000 volt induction motor which is placed between them. As the air temperature may vary over a range from 20° to 200° C and the flow resistance depends on the number of ducts in use and the loading of the reactor, the blowers are fitted with anti-pumping regulators.

Instrumentation in Chemical Analysis

A symposium was held on 20 March, 1958, at the Capenhurst works of the United Kingdom Atomic Energy Authority Industrial Group to discuss instrumentation for chemical analytical work in the laboratories of the Authority. This was limited to senior members of the Authority's staff but the following brief synopsis has been provided.

The morning session, under the chairmanship of Dr. D. T. Lewis (AWRE), was devoted to instrumentation in the laboratory and in a paper "Determination of Trace Components in Gases," A. B. Davies and J. M. Donaldson described the various techniques and instruments used at the Atomic Weapons Research Establishment for the continuous determination of trace impurities ($<$ 100 p.p.m.) in gas streams. The emphasis was on relatively cheap and robust instruments; galvanic, emissive and sonic techniques being most favoured. For the analysis of substantially pure uranium or plutonium solution in static or flowing systems the gamma absorptiometer has many attractive qualities including freedom from contact with the solution being analysed: this instrument and the theory connected with it was described by A. Whittaker (Windscale Works). Experience gained in the use of gamma spectrometry for analysing complex samples with a minimum of chemical treatment was outlined by E. N. Jenkins (AERE, Harwell). A technique under investigation and showing considerable promise is that of X-ray fluorescence spectrometry and details of the present theory and state of development were given by H. M. Davies (AERE, Woolwich). In order to determine the isotope abundance in samples of enriched uranium a simple, inexpensive direct-reading emission-spectroscope has been developed and was described by R. P. Thorne (Capenhurst Works).

At the afternoon session, under the chairmanship of Mr. F. I. Hurley (Capenhurst Works), attention was given to in-line instrumentation for analysis on the plant. H. Bisby (Harwell) described how radioactive techniques could be used to enable radioactive process streams to be monitored by means of their own emission. Difficulties have been overcome and α, β, γ and n monitors have been designed. At the Capenhurst Works an Instrument Development Group provides an instrumentation service for the Authority. Some of the developments such as mass-spectrometers for analysing solid gases and reactive fluoride gases, sonic monitors and single infra-red absorptiometers for gas streams, were described by E. Duncombe, J. Bishop, A. N. Hamer and C. D. Reid. Simple techniques for automatically withdrawing samples from radioactive process streams were described by R. W. Dickinson and F. Jones (Windscale Works) who gave details of a method for continuously monitoring effluent solutions for traces of uranium using an automatic absorptiometer. Gas chromatography also has an application for in-line analyses of process streams containing volatile inorganic halides and the special equipment developed for this purpose was described by G. Iveson (Capenhurst Works).

The Proceedings of the symposium will not be made generally available as some of the papers contained material that is still regarded as secret, but it is intended to publish as much of the material as possible in the usual journals.

In Parliament

RESTRICTIVE PRACTICES IN SHIPBUILDING

In the course of a short debate in the House of Commons last week on restrictive practices in the shipbuilding industry, it was mentioned by Mr. Cyril Osborne (Conservative) that British shipbuilders had booked no export orders at all during the first quarter of 1958, while Germany and Japan had achieved higher productions. Moreover, the Japanese prices were 25 per cent lower than those obtaining in the British shipbuilding industry. Mr. Osborne urged that, in these circumstances, the Minister of Labour and National Service should call a conference of the two sides of the industry in Britain to investigate how far all restrictive practices could be ended, and British shipbuilding prices reduced in order to forestall widespread unemployment.

Mr. Iain Macleod recalled that the House would be aware that the general question of restrictive labour practices had been under consideration by his Ministry's National Joint Advisory Council. The Council had taken the view, with which he fully agreed, that, while they could encourage both sides of industry to set up machinery for examining these problems, it was for each industry concerned to conduct the examination in the light of its own needs and conditions. The shipbuilding industry was doing that.

It was then pointed out by Mr. Osborne that those discussions had been going on for a long time, without, however, producing concrete results. Quite recently, the Cunard Steam Ship Company Limited had cancelled an order for a large liner and the outlook in the shipbuilding industry in this country was very bleak, unless its costs were to be brought down. Mr. Macleod agreed that the problem was a difficult and intricate one. He differed from Mr. Osborne only about the method of tackling it. The Advisory Council and he both felt that restrictive labour practices in shipbuilding could best be tackled through the industry. Recommendations had been made by the shipbuilding Court of Inquiry on this matter only a year ago and some discussions had since taken place. He agreed that progress had been disappointingly slow and he was ready to urge the parties to proceed further, but he believed that the investigation should be left to them.

He would not accept a suggestion by Mr. George Isaacs (Minister of Labour and National Service in the Labour administration, from 1945 to 1951), that previous examination of this problem had shown that there was no real evidence of the actual restrictive practices about which the employers complained.

SHIPBUILDING ORDERS NO CAUSE FOR WORRY

Replying to an inquiry by Mr. Paul Williams (Independent Conservative), as to when deliveries of all types of steel to the shipyards might be expected to become adequate to meet the demands, Mr. T. G. D. Galbraith, the Civil Lord to the Admiralty, said that the production of steel plates and heavy sections was improving. Steel supplies to the shipbuilders should, accordingly, be becoming more plentiful and he hoped that this progress would be maintained.

At the end of March, 1958, Mr. Galbraith continued, there were approximately 6·2 million gross tons of new merchant shipping on order at shipyards in the United Kingdom. During 1957, the number of merchant ships launched totalled 1·35 million tons, but he was not prepared to draw the inference that it would take 4½ years to complete the industry's present order book. He agreed that there was a lot to be said for the view put forward by Mr. Williams, to the effect that some of the most important needs of the industry were to speed up the introduction of automatic devices and to induce everyone concerned to get rid of whatever restrictive practices existed. Arising out of this reply, Mr. Frederick Willey (Labour) suggested that, in spite of the long order books, the absence of fresh orders and the number of orders being cancelled were causing some concern in the industry, but Mr. Galbraith retorted that shipbuilding order books at the present time were about the same as they had been for the last four years and that there was no need at all to worry.

NUCLEAR CARGO SUBMARINES

Attention was drawn by Captain G. R. Chetwynd (Labour) to the need for making more rapid progress in connection with nuclear submarine cargo-carriers. He asked whether it was not the position that Britain was having to concentrate her limited resources of men and money on atomic submarines for war purposes. It would be more desirable in the long-term interests of the country's shipbuilding industry and mercantile marine, he suggested, if Britain devoted her resources in this respect to cargo vessels for peaceful purposes and perhaps relied upon the Americans for information about submarines for war.

Mr. T. G. D. Galbraith thought that Captain Chetwynd was not quite accurate in his information. Work on the submarine was for defence purposes. At the same time, work was going ahead to produce a surface merchant vessel which would be economic. It would be a mistake to divert that work to try to produce a submarine which was also economic. Let us get the surface vessel economic first.

OIL IMPORTS IN BRITISH SHIPS

Information about the percentage of oil imported into this country by ships flying the British flag was given to the House by Mr. Airey Neave, one of the two Joint Parliamentary Secretaries to the Ministry of Transport and Civil Aviation. It was estimated, he said, that in the years 1954, 1955, 1956 and 1957, the amount of oil brought into Britain by such ships had been 41 per cent, 40 per cent, 38 per cent and 36 per cent, respectively. The actual quantity of oil imported by this means had remained, however, at about the same level.

Mr. J. W. W. Peyton (Conservative) asked if the Minister were satisfied that sufficient was being done to maintain a modernised and fast fleet of oil tankers to carry the oil on which this country's economy so greatly depended. Mr. Neave said he agreed that the position required careful watching, but the total British tanker tonnage had increased during the four years in question by about 21 per cent. Many British oil tankers, of course, were employed on voyages which did not bring them to the United Kingdom. The figures he had mentioned related to oil imports into Britain. These had increased from 35 million tons to 39 million tons during the four years 1954 to 1957.

TRAINING FOR SKILL

Mr. Reginald Moss (Labour) wanted the Minister of Labour to encourage industry to draw up detailed syllabuses for the training of apprentices. He emphasised that the Carr Committee, which investigated this matter, had recommended not tests for apprentices but detailed syllabuses, which would be an advantage to some industries and ought to be considered by all. He agreed that in their report *Training for Skill* (H.M.S.O., price 1*s.* 6*d.*) the committee had suggested that this action should be taken by industry; nevertheless, the Ministry of Labour could do something.

The Parliamentary Secretary to the Ministry, Mr. Richard Wood, said that the report recommended that each industry should consider the introduction of detailed training in the light of its own circumstances. In fact, the committee took the view that, while detailed syllabuses could help to maintain high standards of training, there was a danger that they might lead to inflexibility unless sections of industry were enabled to make up their own minds in individual circumstances. Mr. Wood said that the recommendation in the report that industry should set up a National Apprenticeship Council had recently been considered by the National Joint Advisory Council of the Ministry of Labour. The Council had agreed generally that a central body of that nature was needed and that its constitution and scope should be considered in the course of joint discussions, which would take place shortly. The report had been brought to the attention of the appropriate employers' and workers' organisations.

RAILWAY BRAKED WAGONS

Asked to give the reasons for the reductions in the railway brake conversion scheme, Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, said that the programme for converting existing wagon stock had been reduced as a result of the capital investment cuts for 1958 and 1959. In addition, the programme for fitting 16 ton mineral wagons had been interrupted because it had been found that the braked wagons could not be handled by some of the old types of tippler gear at industrial plants, until some modification of those types had been carried out. A substantial reduction in the programme as a result of that difficulty was not likely.

Any financial arrangements to be made in respect of uncompleted contracts, he told Mr. D. H. Howell (Labour), were a matter for the British Transport Commission, but he had been advised by that body that the cost to them of the revision of these contracts would be very small in relation to the total sum involved. Both his Ministry and the Commission would do their best to get the work moving again.

Assessing Value of Research

The Council for Scientific and Industrial Research has recently set up an Economics Committee to advise the council on the economic aspects of their scientific research policy and on the probable economic value of particular researches. According to information given by Mr. Harmar Nicholls, Parliamentary Secretary to the Ministry of Works, to Mr. Leslie Thomas (Conservative), the chairman of the new committee will be Professor E. A. G. Robinson, Professor of Economics at Cambridge University.

Hydraulic Transport of Solids

Research efforts by the British Hydromechanics Research Association, supported by the DSIR, have considerably advanced the basic knowledge necessary to enable the hydraulic transport of solids to be made a commercial proposition. Mr. Harmar Nicholls told Mr. Bernard Braine (Conservative) that these results were now being applied by industry in this country. A good example was the removal of spoil at the tunnel under construction at Purfleet. Experiments were continuing in the mining industry.

Diesel Crankcase Explosions

Dangers arising from explosions in the crankcases of diesel engines were again referred to in the House. On this occasion, Dr. R. F. B. Bennett (Conservative) wanted to know what research had been carried out for the prevention, rather than the cure, of crankcase explosions in diesel engines, particularly large marine diesel engines. The Parliamentary Secretary to the Ministry of Works, Mr. Harmar Nicholls, said that the British Shipbuilding Research Association, supported by the Department of Scientific and Industrial Research, had carried out fundamental work in collaboration with the Imperial College of Science and Technology on the causes of such explosions in large marine diesels. The work had led to the development of a photo-electric automatic device to give an early warning when dangerous conditions were arising, so that remedial action might be taken.

Following extensive trials at sea, this device was now being manufactured commercially. There was another device for the same purpose. It was being developed independently and would also be available commercially.

The Human Element

The Creative Motive

" If we resist new ideas and stifle man's imagination, the effect will be similar to that of pouring sand into a delicate mechanism. But, if right ideas are fostered and made effective, the effect is similar to that of correctly lubricating a highly stressed and valuable machine." These words were taken from a pamphlet published by the Guildford and District Productivity Association which was formed in 1953 under the sponsorship of the British Productivity Council " to bring together all those interested in productivity in its area."

The pamphlet, which is attractively produced and well written, is entitled *Ideas at Work*. It aims to popularise suggestion schemes and provides guidance on how such schemes should be started and run. A suggestion scheme which works well is described as " a positive and practical way of stimulating increased productivity." Every enthusiastic business should include one and in each case the scheme should be the firm's own and reflect its character as other functions do. To be successful, a suggestion scheme should be evolved from the business it is to serve. It must not be a ready-made scheme installed and left to its own devices. It should be the kind of thing which is required to encourage people to think constructively about their work and their firm, and to channel these thoughts into practical application or use without much effort.

The leaflet sets out the framework of a successful scheme. The accent is on simplicity and vitality. Several of the rules stated apply to anything a firm does if it is to succeed, but it is a very useful way of testing the effectiveness of management at all levels. It is one of the best methods tried so far to enlist the support and contribution of every employee. Although suggestion schemes tend to work best in the most efficiently managed concerns, they have a part to play in all kinds of firms and their failure is an indication more reliable than most that all is not well with the management.

Dangers in State Pensions

The pension plans currently being considered by the political parties were referred to by insurance company chairmen in their annual statements. They welcomed the idea of spreading the occupational-pension habit, but warned against having a huge State fund which would ultimately have the power over the planning of the bulk of the country's personal savings. In their view, the disposal of policies among many competing private organisations would mean greater flexibility and cater better for individual needs.

The insurance companies are naturally enough not very keen to be faced by a large national concern competing with the existing schemes already provided. They would like these made use of and expanded. There is, moreover, one danger in any State action—that it should cover an attempt to " redistribute " income between income groups. It is doubtful if further redistribution would make a significant contribution to social capacity. It may well do the reverse, by diminishing opportunities and sapping the individual's desire to better his status.

Sooner or Later?

The commission on the Co-operative Movement which has been at work over the last two years published its report last week. It is a highly critical but constructive document. Broadly it says that the movement has not moved with the times in methods of organisation, levels of salaries for managers, size of economic producing and distribution unit and financial policy. It accepts, as it had to, the basic idea of democratic control by committee which underlies the movement but it took little else for granted. Even the " divi " has come under fire as an idea. It was originally conceived as a payment to co-operators for their support of a sound and efficient economic idea. It has for long been something else and now it is proposed that it should be a residual item. The word could not be used perhaps but it is in fact suggested that the " dividend " should be nothing else than a profit.

Mr. Gaitskell and his committee (which was fairly independent, having professional consultants and economists on it as well as well-wishers of co-operation) have produced an incisive report calling for a drastic rationalisation of the whole structure. The big problem remains, of how to get the movement to administer the drastic but wholesome medicine suggested. It may have to do so quickly or be left behind in an age of revolutionary changes in distributive organisation.

Towards Overall Efficiency

According to the latest figures of the Ministry of Labour there is a small but perceptible trend away from payment by results. In the industries covered by the Ministry's enquiry the fall was from 32 to 31 per cent between 1955 and 1957. This is only a slight decline but there may be added significance in the fact that it seems to have been apparent especially in large concerns. There have been indications for some time that certain companies preferred to pay high time rates rather than run some form of incentive scheme and the trend has been growing for some years, in the United States as well as here.

On the other hand there is no sign of a decline in the application of work study methods. There would therefore be grounds for thinking that work study is being less and less thought of as a way of introducing bonus incentive schemes. Such a development would be much to the liking of work study engineers. They have been made acutely aware that labour in particular has viewed work study, especially the time and motion side of it, as an outgrowth of rate cutting by stop watch. Work study can therefore rely increasingly on justifying its application to management in terms of all round improvements in efficiency in the factory and office and not just upon higher earnings for higher output.

AEU's Dim Outlook

The annual meeting of the Amalgamated Engineering Union produced a unanimous endorsement of an immediate demand for a substantial wage increase. Taken in the shadows of the London bus and railway dispute, the decision made clear how far the Union stands from the Government's policy on prices and wages. The resolution and the meeting were uncompromising: no increase will be accepted with " strings " as last time when the AEU accepted a pay rise in exchange for a promise not to make the claims for 12 months; it must be retrospective to the date of application; if no settlement is reached within three months " a policy of direct action " will be employed. In addition, a demand for " the utmost vigour " in pursuing the claim for a 40-hour week was coupled with the wages resolution, mentioning " action to enforce this long overdue reduction in the working week."

The AEU's attitude seems to have hardened considerably since last year. Both demands are to be supported by publicity campaigns—the first by special meetings in all parts of the country addressed by members of the AEU executive, the second by the use of " all available media." Most speeches were hostile to the Government and it is clear that the Union leaders look upon Mr. Macmillan's policy of price stabilisation as an attempt at curbing the Unions' power through deflation and unemployment. The prediction by one delegate—Mr. R. A. Etheridge of Birmingham—that there would be one million unemployed by Christmas, suggests that this possibility is uppermost in the thoughts of AEU leaders at the present time. Hence, perhaps, their intransigence.

Assisted Sandwich Courses

A joint statement has been issued by the Ministry of Education and the Federation of British Industries about advanced sandwich courses. The aim is to improve the financial circumstances of young men in employment in industry who are undertaking a sandwich course and who are at present at a disadvantage financially compared with those who are doing full time courses.

The FBI recommends to its members that companies which already pay their students' fees and remuneration while at college should continue to do so. Firms adopting sandwich courses in the future are asked to keep this system before them as one worth copying. They think that it strengthens the student's loyalties to the company and brings the company closer to the college. The Ministry is recommending to local education authorities that they should give sympathetic consideration to applications for maintenance awards for periods separately spent in college. A student's work period should normally be considered self-contained and his earnings should not be taken into consideration in fixing an allowance from the local authority. Recommendations are also made about giving a " kitting out " allowance and *ex gratia* payments at the end of a course.

Among other gains here there is slight progress away from the means test for a student and his parents before a grant is made. It might yet be the valuable thin end of a very thick wedge.

Seeking Work

Having not enough to do is the principal of 18 reasons for changing jobs given by a sample of London's 15,000 secretarial and clerical workers. Many firms have complained of a high turnover among such staffs, which led Miss Elizabeth Pepperell, assistant director of the Industrial Welfare Society, to carry out a survey.

The results are a good illustration of the fact that in practice few young workers change jobs primarily to seek higher pay. They reflect young people's wish for efficiency—at least on the part of their bosses—and their liking for modern well-equipped offices. The first six of the reasons listed by Miss Pepperell were as follows: not enough to do; not enough discipline; irritation at bad planning of work; poor and out-of-date equipment making it impossible to do good work; fear that increasing mechanisation will lead to an increasing number of boring jobs; and not knowing how they stand in their bosses' opinion. Among the other 12 are several concerned with the lack of prospects for promotion, the desire for better furniture and too much noise in offices. Another—topical as we go to press—is the tedium of long journeys to London and the desire to work closer to home.

Miss Pepperell's survey is a useful reminder of many aspects of employment too often forgotten. Many of the reasons she lists for leaving a job must be also reasons for not taking the next one. Yet two reasons which so often prompt young office workers to move—the wish to meet new faces and the hope to gain useful experience—are not included among those given.

Report of "Engineering" Inquiry into the British Aircraft Industry

Some Questions put to the Companies

During the inquiry a series of questions were put to representatives of the aircraft companies. To many questions direct answers could not be given; some questions did not apply in particular cases; others overlapped; and as the inquiry proceeded new questions arose and were added to the list. For these reasons, the questions were not considered formally but rather as talking points. The final list appears below.

(1) With what other companies, at home and abroad, is your company associated?
(2) What is your company's annual turnover?
(3) Roughly how many people do they employ?
(4) List present products and any planned or under development.
(5) How much of your company's work is subcontracted to other firms?
(6) How much subcontract work does your company undertake?
(7) How much current work and how many existing contracts extend into the future?
(8) How long is this work likely to last?
(9) What is the extent of maintenance, overhaul and repair work on products already in service?
(10) To what extent have your company depended on research grants from Government bodies in respect of military production?
(11) What types of military aircraft are likely to remain in demand?

* * *

(12) What is the relative importance of your company's civil and military work?
(13) How long have your company been working in the civil aircraft field?
(14) To what extent do you consider the Government should now be prepared (if at all) to promote the development of civil aviation so as to ensure a continuity of research and development in air communications?
(15) Do you regard the civil aviation field as offering good prospects for British aircraft companies?
(16) What types of civil aircraft seem most promising for manufacture and sale during the next ten years?
(17) What are your views on the straight jet versus propeller turbine controversy as it affects the civil field?
(18) What problems arise when a company transfers its main production effort from military to civil aircraft?

* * *

(19) Do your company need to diversify their products in the light of reduced military contracts and curtailed Government expenditure on development work?
(20) If so, roughly what percentage (in turnover or employment) have they to make up?
(21) What diversification are your company likely to adopt or have adopted; what new products?
(22) Why have you chosen this particular form of diversification?
(23) What non-aircraft products do you already make?
(24) In taking up new work would you prefer to tackle novel and unexploited products (possibly requiring some development) or established products?
(25) Have you already or do you plan to seek manufacturing licences from other (home or overseas) companies?
(26) Do you propose to sell manufacturing licences or enter into technical exchange agreements?

* * *

(27) How can your existing equipment or products be applied to non-aircraft purposes; for example, propellers for wind generators, light-alloy sheets for housing, vibration test apparatus for motor-car work, plastics for fuel tanks or packaging?
(28) If you have already diversified, did you find that your existing proportions and distribution of labour (for example, design and development to production staff) and plant (for example, special-purpose to general-purpose tools) were about right?
(29) Do you consider that aircraft and other products can be made economically in the same factory?
(30) Is it your company's policy to buy other businesses?
(31) What businesses have been acquired in the past?
(32) Do you consider that the new situation will call for a redistribution of your company's resources (financial, human and technical) within your organisation?
(33) If a reorientation becomes necessary, how do you propose to make full use of existing skill and experience (craftsmen, draughtsmen, designers, managers, directors)?
(34) What roughly is the proportion of production operatives to design and development staff in your company?
(35) In making a changeover, do you plan to introduce specialists from other fields?
(36) Is any change you may envisage likely to require an alteration in your management structure?
(37) What problems have arisen in the past when your company have been called upon to digest new kinds of product or situations?
(38) Do you anticipate a fall in profitability or tighter profit margins in changing over from aircraft to other products or from military to civil aircraft?
(39) List special-purpose tools in use and suggest non-aircraft products to which they may be applied.

* * *

(40) Have your company already or do they propose to establish or hire the services of a market-research group?
(41) How does your company launch a new product commercially?
(42) In the past when your company have developed a new aircraft, has it been on the basis of a specification supplied by an airline or Government body or has it been a venture for which your own company has predicted the demand or provided the capital?
(43) What numbers of your past aircraft designs have fallen into these two categories?
(44) What proportion of your present turnover arises from exports?
(45) What approaches can you suggest for overcoming the depression in the aircraft industry?

Background to the Inquiry

ENERGY and imagination have been bred in the British aircraft industry by its brief history of constant change. Repeatedly called upon to assimilate technical discoveries and to adjust itself to fluctuations in military requirements, it has achieved an adaptability unequalled by any other industry. The manner in which it is coming to terms with the current shortage of aircraft work may therefore be of general interest. The Minister of Supply is expected to make a statement on the aircraft industry's problems soon.

The situation is not entirely new; to some extent it has existed since the war, but recently it has assumed a new seriousness. Just over a year ago, in April 1957, the Government published the dramatic Defence White Paper in which a new approach to military preparedness was outlined. The manned fighter was to end with the models already adopted and the projected supersonic bomber was to be discontinued. Guided, ballistic and nuclear weapons were to take their place. At the same time Government expenditure on aircraft and engine development was severely curtailed. For companies dependent on military work this was a serious blow. In the following months the Government's attitude seemed to soften slightly, though there was no evidence of any financial relaxation. In the White Paper *Report on Defence*, published in February this year, there was greater emphasis on conventional forces for frontier defence and localised emergencies.

How this vigorous industry with its vast reservoir of talent has responded to the situation has been the subject of an inquiry carried out by ENGINEERING. We have visited some twenty companies and had conversations with designers, project engineers, sales managers, research workers, chief engineers, chief designers, and directors. In addition, we have received comments from Members of Parliament (including a former Air Minister), the chief engineer of BEA, and representatives of BOAC, and the Society of British Aircraft Constructors. The report assesses the response of the aircraft industry to the current situation, gauges its effect on the industry and examines the action being taken, the new strategies and product policies adopted and the new products being made.

Contents of the Report

Report on the ENGINEERING Inquiry into the British Aircraft Industry is divided under the following headings:

Aircraft Companies Look at Policy and Action — *page* 594
How the Aircraft Companies are Responding — *page* 598
- By Forming Groups
- By Choosing Promising Military Work
- By Building Civil Aircraft
- By Diversification

New Products — *page* 601
Making the Changeover — *page* 602
- Work in Hand
- Reorientation
- Converting to Civil Aircraft Production
- Selling Civil Aircraft
- Diversification Problems

A Comment on Engines — *page* 603

Continuing **Report of the "Engineering" Inquiry**

AIRCRAFT COMPANIES LOOK AT POLICY AND ACTION

AN aircraft is a concise expression of accumulated technical wisdom. Into its fabric is woven a unique combination of many threads—skill, experience, know-how and the precision of highly refined equipment and techniques. Cut off the aircraft and there are innumerable loose ends, none of which can be knitted neatly into a new pattern or even a complex of patterns.

The Government, who are mainly responsible for the present disturbance, are also seeking a solution to the problem, and shortly a statement will be made in Parliament on the findings of an interdepartmental committee.

The Minister of Supply, Mr. Aubrey Jones, stated when the committee was established, that "the purpose of the study by senior officials of the Departments concerned is to assess the national importance of the industry and, in the light of this assessment and of recent defence changes, to make recommendations to Ministers on future Government policy towards the industry and in particular on the scale on which the Government should continue to support aeronautical research . . . The inter-departmental study will certainly take account of the possibility of diversifying the industry's products, but action on this lies primarily with the industry itself."

GOVERNMENT CONTRACTS

The industry's difficulties have been clearly indicated by Sir Reginald Verdon Smith, chairman of the Bristol Aeroplane Company. Writing in the latest issue of *Bristol Review*, he declares that it "is now very clear for all to see that we are encountering the first consequences of two critical decisions which the Government has taken—the first that defence requirements of manned aircraft are to be severely cut, and the second that direct financial support will no longer be given to the development of new civil aircraft and aero-engine projects. These decisions affect fundamentally both the size and pattern of the aircraft industry. Figures published by the Government show that 80 per cent of research and development expenditure incurred in the industry in 1956 was on direct Government contracts and we all know that the proportion of production effort related to defence far exceeds the proportion devoted to civil aircraft. . . . On the civil side the Government has been increasingly unwilling to finance development, and we have in fact already invested several million pounds of the Company's own resources in the development of the Britannia. These resources are, however, not unlimited and we cannot take on all we should like to do. When, therefore, the Minister of Supply told us recently that the Government was no longer willing to support the development of the Orion, whose completion would cost upwards of £5 million, we had regretfully to decide that we could not carry on the development of this engine at our own expense in the absence of firm orders for production quantities."

Mr. John Dudley North, chairman of Boulton Paul Aircraft Limited, has further remarked that over "the whole history of the aeroplane, the military side of aviation has always provided a much larger market than commercial flying; in fact it would scarcely be an exaggeration to describe civil aviation as a by-product in that so much of the research and development which has gone into military aircraft has formed the basis of corresponding development in the civil field." The chairman of Blackburn and General Aircraft Limited, Mr. Eric Turner, has also described aircraft manufacture as "basically an armament industry."

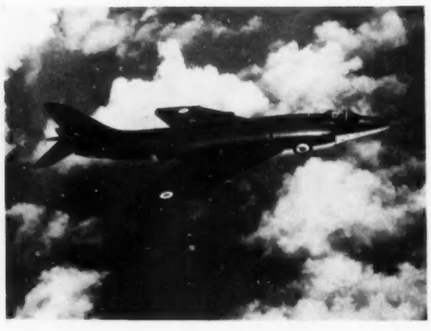
This sombre view of the situation is supported by the great majority of aircraft firms. Rolls-Royce indicate a period of careful husbandry ahead; de Havilland, though well placed in the civil field, have a major proportion of military work which they regard as a wasting asset; Hawker Siddeley say they have lost out badly on Government business (the Hawker Hunter is Britain's standard operational fighter); Armstrong Siddeley Motors observe that there is some cause for anxiety but that they are undismayed, noting that engines have in general been less badly hit than airframes; Vickers, whose subsidiary Supermarine are almost exclusively devoted to military production, feel, in spite of their great success and prospect of further successes in the production of civil aircraft, that the position is less favourable than it has been; one company director has remarked that it is difficult to imagine any product quite as unprofitable as aircraft are at present—"all the aircraft firms will be bust in five years if they go on as at present." A spokesman for Armstrong Siddeley Motors considers that the aero-engine companies may have to transfer a third or a half of their energies to other work. According to one opinion the number of people employed by the aircraft industry is likely to decrease during the next four or five years from its present 250,000 to some 150,000.

But others are more confident; a chief engineer declares that employment will not fall much below the 200,000 mark and even if it did there would be no cause for alarm; indeed after the War it stabilised quite comfortably at 175,000, and was only inflated later by the Korean emergency. There is certainly no despair, and many, such as de Havilland, regard the present problems as temporary, "a mere flutter on the surface which will be resolved in 10 years." It has been suggested that the total expenditure on aeronautical devices, including electronic work for guided weapons and other purposes, may not in fact have altered substantially. Many firms, Blackburn for example, claim that they have all the aircraft contracts they can cope with. The Gloster Aircraft Company have a fairly substantial order for Javelin all-weather fighters, and will not be called upon to seek new work for at least six months. Others, such as Westland Aircraft Limited, who are concerned mainly with helicopters, state that they are expanding—purchasing new premises, hiring new drawing-office staff, even subcontracting drawing-office work, and complaining that they can neither find all the technical staff they require nor adequately tackle their research programme. The de Havilland Engine Company estimate that on the production side they can employ all their facilities for the next three years at least. Vickers-Armstrongs (Aircraft) Limited are likewise thoroughly occupied on civil aircraft work. The lively activity of subcontractors engaged in component manufacture also gives evidence of a fairly healthy climate: British Thomson-Houston, whose pioneering work on the jet engine is sometimes forgotten, appear to be pursuing a flourishing business on aircraft systems and electrical plant. Aero-engine work has suffered to only a limited degree: thus Rolls-Royce control over half the world's civil jet-engine market.

LONG FORESEEN

The industry has not been taken aback by the current crisis; indeed it has long foreseen it. In 1956, before publication of the Defence White Paper, Mr. Turner, of Blackburn, stated in his address at the company's annual general meeting: "It seems likely that the demands made on the industry for the production of conventional military aircraft will decrease and that the industry as well as the Services will have to face a period of change and readjustment. There is, however, one field in which (Blackburn are) very much interested, namely, that of transport aircraft, where our national efforts should be increased rather than lessened." Mr. Turner assured ENGINEERING that his company had begun thinking along these lines well before 1956. Such foresight is almost certainly not unique; Bristol, for example, anticipated the trend towards guided weapons, developing the Bloodhound.

The Fairey Aviation Company faced the threat in very good time and not only entered the guided-weapon field, but have pursued a consistent diversification policy since the war. Hawker Siddeley, by repeatedly adding to their now enormous group, have secured their future, at least financially. Short Brothers have been diversified for some four years, having established precision and general engineering divisions partly for this purpose; they claim to be the largest manufacturers of analogue computers outside America. F. G. Miles Limited recognised long ago the danger of putting all their eggs in one basket, and have demonstrated that even a comparatively small company can run a comfortably diverse business with success.



Aircraft: Military

Research

Civil

Nevertheless, many firms, including those considerably diversified, have confirmed their faith in aircraft manufacture. Sir Reginald Verdon Smith has made a point of emphasising that Bristol will remain an aircraft company. English Electric, who make what is nominally to be the last British manned fighter, the P.1 B, intend to stay in the aircraft business, though the company's many other interests would make it safe to withdraw if they did not consider aircraft a profitable enterprise. Curiously, English Electric were the only electrical group to enjoy an entirely successful financial year. The chairman of Blackburn told our representative: "We are basically an aircraft company and intend to remain basically an aircraft company." There is also something to be said for the view that if there is to be a wholesale retreat from aircraft manufacture, the few that stay will operate under favourable conditions. It has been said that the aircraft industry becomes increasingly difficult to isolate either statistically or descriptively owing to its extensive diversification, and that in two or three years it may be impossible to do so. But it should be emphasised that in most cases the new fields of manufacture adopted or proposed are intended merely as a compensating activity to allow for fluctuations in the basic aircraft business—in the words of Mr. Eric Turner, a policy of "belt and braces."

DIVERSIFICATION

Emphasising the view that diversification should be pursued, if at all, as a supplement to the aircraft side in order to sustain it, Mr. R. E. Harvey, general manager and assistant managing director of Short Brothers and Harland Limited, told ENGINEERING that "the aircraft industry does not anticipate a recession of such a duration and of such dimensions that it should reduce its aircraft manufacturing facilities for all time." Given this conviction there appear to be two courses open to any company. They can reduce the size of their labour force, and seal off that part of their facilities in temporary disuse; or they can venture into diversification with the known risk that by the time plant and personnel are adapted to the new products the aircraft market may be placing renewed demands on their capacity. If this second course is adopted, the company will later be faced with a further problem when aircraft demand recovers: unless the flexibility afforded by the diversification already undertaken and its associated income are to be sacrificed, it will be necessary both to keep the new products going and also to expand the depleted aircraft capacity.

Theoretically, the industry would undertake new expansion for every fluctuation in the trade cycle. Vickers-Armstrongs (Aircraft) confirmed this view; a company is never static, it is either growing or declining; if they have any faith in the future they will wish to retain their technical and workshop staff, who may be needed again later; each successive growth will therefore be consolidated through an irreversible process. Other factors will of course modify the effect, but there will be a trend in this direction. What is more, there will be a progressive tendency for the industry to lose its character as non-aircraft appendices continue to be added.

Some of the larger companies are able to employ a further mechanism which affords a certain flexibility. Aircraft construction has been described as an assembly industry, though this is perhaps misleading, but it is certainly true that an immense amount of work is subcontracted. Assemblies of, or complete, Bristol Britannias, Vickers Viscounts, English Electric Canberras, Hawker Hunters, de Havilland Sea Vixens and almost certainly Comet 4s too in the near future may be seen in half a dozen factories throughout the country. This work is in addition to the normal procedure of subcontracting specialist work such as engines, undercarriages and control components. There are in fact friendly relations if not formal associations between most members of the industry. Thus Rotol is a joint propeller company owned by Rolls-Royce and Bristol. However, should there be a contraction in orders, it is reasonable to suppose that the company promoting any aircraft will bring back the work as far as possible into its own premises, thus compensating for any shortage. For the subcontractors the consequences would be less satisfactory. This mechanism is, however, of limited application. As will be explained in a later section, it is essential, particularly in the case of civil aircraft, to minimise the lead time between receiving an order for a batch of aircraft and meeting it. Use must therefore be made of the maximum simultaneous capacity, so that work must necessarily be farmed out. A proposal that Bristol build all their own Britannias so spinning out the work for a number of years would not be regarded sympathetically by the airline operators. Time is the all-important factor in aircraft work. To some extent, nevertheless, the excess of regular outward over inward subcontracting is a measure of a company's stability. Certain companies, Vickers-Armstrongs (Aircraft) for example, have not had cause to take in subcontract work for some years.

Probably the most familiar approach to economic viability is membership of a large group of companies making different products. (The amalgamation of a number of aircraft firms is a different matter and will be treated later.) By purchasing or establishing new companies with products ranging from steel to traditional housing, as have the Hawker-Siddeley Group, a company can achieve a high degree of flexibility: investment can be allocated to whichever company requires it at any given time and income is assured whatever the fluctuations in particular markets. Blackburn have similarly diversified by the acquisition of other manufacturing concerns. The procedure may conveniently be called financial diversification. Control of the member companies, which are virtually autonomous, is effected almost exclusively by financial means, though possibly in the early stages only. In the case of Hawker Siddeley and Blackburn the aircraft companies provide the nucleus, but the converse is true for the English Electric Company, which though having a long aeronautical tradition through one of its subsidiaries, the Coventry Ordnance Works, built up an aircraft division on its existing structure. Somewhere between the two is the Vickers Group, the aircraft side of which has grown up alongside other sections of the group's work. The Hawker Siddeley Group, which spreads it interests by purchasing new assets and possibly disposing of others, represents a form of diversification in which initially at least capital alone is redeployed.

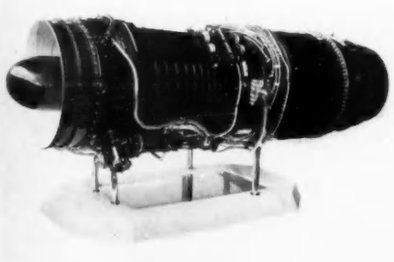
The redeployment of all existing assets—capital, manpower, capacity and plant—is a second more complex kind. The nature of aircraft construction, with its highly specialised production methods, makes full diversification impossible or at least hazardous. Between the two there are countless intermediate approaches. The Fairey Aviation Company, for example, have successfully undertaken detailed diversification with many of their resources redistributed and many products adapted to non-aircraft purposes; thus part of the Fireflash guided-weapon team with its capacity for fundamental study has been transferred to nuclear research, and instruments developed for military work have been adapted for mining and other applications. In many cases new manufacturing divisions are formed, which are often later registered as companies.

De Havilland Propellers Limited have also discovered wider applications for their products —propellers for wind-driven power generators, for example, and for cooling installations; their vibration test apparatus has been used by Cadbury's for getting the bubbles out of milk chocolate. They now have propellers and missiles as their main line and should readily expand into industrial electronics and plastics.

NUCLEAR POWER GROUPS

Diversification may be undertaken, not to achieve economic viability but with the more immediate object of putting to use space and personnel temporarily redundant; in other words as an excuse for retaining staff and premises until the recession is over. Again, it may represent a natural evolution in the company's policy. Thus the de Havilland Engine Company and Rolls-Royce, whose interests have always lain in the propulsion field, have both formed nuclear power groups in order to study the mobile applications of certain nuclear reactors. De Havilland are understood to be investigating the very promising high-temperature gas-cooled reactor. Projects of this kind clearly represent a long-term adaptation, not an emergency measure arising from the present situation. Their purpose is to make full use of the company's background and experience and of its personnel and manufacturing facilities.

The aircraft industry has a high proportion of design and development engineers to shop-floor production workers—as high as 1 : 1 in guided-weapons and electronics divisions. Aircraft firms might therefore be expected to take up new and unexploited products requiring some development, rather than products already on the market. Unfortunately in some cases Govern-



Engines

Guided Weapons

Non-Aircraft Products

Continuing Report of the "Engineering" Inquiry

ment work has been discontinued at such short notice that for immediate purposes well-tried products may be the only choice. (There is a three-months' break clause in certain Government contracts and one firm had an order for Canberras cut by roughly half.) Thus, if a healthy labour force is to be maintained it may be necessary at the beginning to purchase know-how in the form of licences, with development work phasing in later. It follows too that in entering other fields the industry is likely to subsidise its initial sales in order to gain a foothold. "No one can break into a new market and make money at the same time."

The changeover will almost certainly be expensive. What is more, few products can carry such high overheads as an aircraft. In terms of the numbe ıof sq. ft of floor space per working man, the expenditure on lighting and heating, and the amoı ıt of paper work involved, aircraft construction is extremely costly. Even conversion to guided-weapon production (which invoives as much electronics as aerodynamics) presents a major problem since the floor-space requirement is much reduced. The fundamental problem in partial diversification, as Mr. B. S. Shenstone, chief engineer of BEA, has pointed out, is to manufacture at two entirely different levels of quality and yet achieve reliability; it has been shown practically impossible, he says, to mix aircraft and other work in the same factory.

Nevertheless, the entry of aircraft companies into new fields may have an invigorating effect on certain older industries; by introducing new ideas they may catalyse rapid changes. Saunders-Roe, for example, have developed a hydrofoil boat for the Royal Canadian Navy, and Fairey in collaboration with Ferranti have designed and built an advanced three-dimensional electronically controlled milling machine. It is also conceivable that fundamental technical ability, of which the aircraft industry has an abundant share, can be sub-let, as is computer time—thus the industry's highly qualified engineers and scientists might serve as technical shock troops to be brought in wherever Britain's advancing technical front appeared to lag.

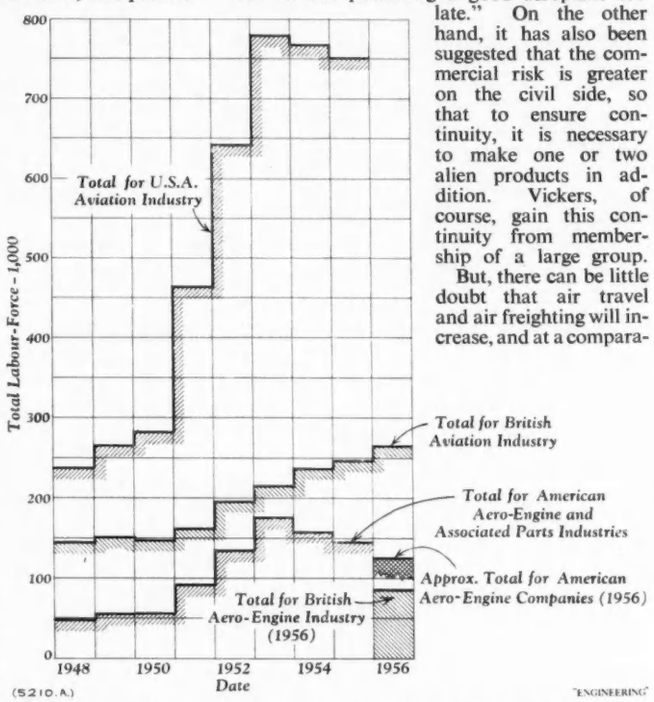
The high proportion of design and development staff to production workers on the shop floor is very striking, and further complicates the problem of taking up commercial products. Folland Aircraft Limited, for example, have one designer, draughtsman or research worker, for every four workshop operatives. The total number of employees (including administrative and cleaning staff) both in Rolls-Royce and Blackburn contains some 20 per cent engineers, and for Westland the figure is 10 to 15 per cent. Short Brothers and Harland, arranging the quantities in a different way, give the ideal figure for the aircraft industry of one direct production worker to one indirect worker, though recognising that the ratio in practice is more like 1 : 1·5. Short Brothers also give a proportion of 1 : 2 for entire technical staff, including draughtsmen, to direct production workers. Mr. H. G. Conway, chief engineer and assistant managing director of Short Brothers and Harland, stated to our representative that in the company's guided-weapon division 295 production staff were kept going by 220 engineers.

Any aircraft or guided weapon will contain in its cost a very high expenditure on design and development. The designing of one aircraft may employ 200 draughtsmen for three years at a total cost of £1 million. Full development of a single large aircraft may cost from £20 million to £45 million, and of an engine from £5 million to £15 million.

CIVIL AIRCRAFT

So far we have made no reference to the most natural and promising outlet for the aircraft maker's energies—the civil aircraft field. Certain firms—Vickers with their Viscount for example—have already shown that, in spite of the fundamentally military basis of the British aircraft industry, British firms can prosper in this direction. Indeed, Vickers-Armstrongs (Aircraft) state that they do not propose to diversify any further, but intend to consolidate their present successes and concentrate on large aircraft, since it requires so much effort in design and production engineering to meet target dates. "It's no use producing a good aeroplane too late." On the other hand, it has also been suggested that the commercial risk is greater on the civil side, so that to ensure continuity, it is necessary to make one or two alien products in addition. Vickers, of course, gain this continuity from membership of a large group.

But, there can be little doubt that air travel and air freighting will increase, and at a comparatively rapid rate. In 1955, 68 million passengers travelled on scheduled flights throughout the world (excluding China and the U.S.S.R.), and in 1957 the figure had already risen to 87 million. The increase per annum is roughly 10 per cent, a figure which also applies to BEA traffic. If it is assumed that each flying passenger makes two flights a year—a comparatively modest estimate—it will be seen that little more than 1 per cent of the world's population travels by air; the percentage by weight of freight is markedly smaller. It will therefore be apparent that the scope for expanding civil aircraft production is vast, even excluding any business in special-purpose, private and executive machines, such as the successful light machines for agricultural and other uses made by Auster Aircraft Limited. There are also many openings for less spectacular but workmanlike feeder-line aircraft, such as the Twin Pioneer built by Scottish Aviation Limited, and the Handley Page Herald. As yet the United States accounts for some 85 per cent of the world's civil aircraft production; Britain, France and Holland share most of the remaining 15 per cent. Now that British firms are free from military commitments, they can concentrate their attention on increasing this proportion. In a later section of this report there is a discussion of the types of civil aircraft planned or showing promise.

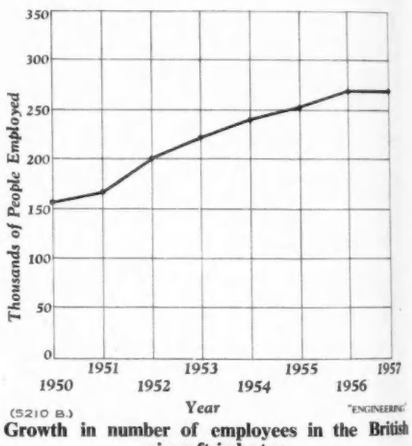


Employees in the British and American aviation industry, and the two engine industries.

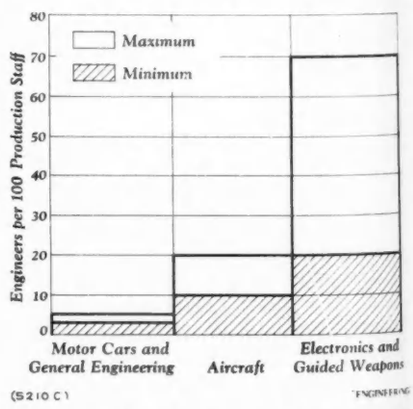
EXPORT INTELLECTUAL CONTENT

Much has been written of the export value of aircraft. The aircraft industry is already Britain's second greatest exporter of manufactured goods, and with its capacity for growth it may eventually take first place. In 1957 ships were second but have now been overtaken. As a dollar earner, aircraft are somewhat less successful, falling considerably below motor-cars and whisky; but rather more important, they are a dollar saver, in that without a British aircraft industry to serve the home market we should be dependent on the purchase of American machines. Short Brothers export over 50 per cent of their aircraft products. The entire industry's exports for 1957 are estimated at 24 per cent of total output, with a value over £100 million. For a country dependent on selling in a world where even backward countries are already capable of making lawn mowers and other simple equipment, there is good reason to concentrate our attention on products that have a high intellectual content. Aircraft are almost unequalled in this respect. But in the view of Vickers, who have ample experience, to succeed overseas, producers require a sound home market—if only as recommendation to the potential overseas customer. Also necessary is an explicit Government policy. In the words of Mr. Eric Turner: "We must have an aviation policy, which at present we have not."

The matter of Government financial support is a vexed question, and in visiting aircraft firms



Growth in number of employees in the British aircraft industry.



Number of technical personnel per 100 production employees in general engineering, aircraft and electronics.

it is not surprising that the impression gained has something of a bias. Nevertheless Vickers-Armstrongs (Aircraft) are building both the Vanguard and the VC 10 without direct Government assistance, and the Gnat and Gnat Trainer made by the comparatively small Folland firm are both private ventures. Yet the engines for all these aircraft—the Rolls-Royce Tyne and Conway and the Bristol Orpheus—have all been partly sponsored by the Ministry of Supply, and it is arguable that without repeated financial infusions—to which the airframe side has also been accustomed—development might well run down.

Obviously no country should live beyond its means, and the market place is the only yardstick that we have for valuing a product; but to miss a juicy profit for lack of adequate investment is a most grievous thing. To provide sufficient resources for modern aircraft production, companies have been encouraged to form groups or joint undertakings, rather like the atomic energy consortia. De Havilland, Fairey and Hunting Aircraft Limited, for example, have set up the Aircraft Manufacturing Company Limited, as a joint concern to build the short to medium range DH 121. Mr. Geoffrey W. Hall, chairman and managing director of Fairey, has said "Enforced rationalisation could readily squander the long background of experience and the competent teams which have been built up over the years." He advocates collaboration rather than mergers or state control.

Others consider that Government money might without major sacrifice be transferred from military to civil development. Possibly the Armstrong Siddeley engine projected for the cancelled supersonic bomber could be continued in the interests of a supersonic airliner. Indeed, it would be tragic if our lead in the straight-jet and propeller-turbine field, which we may hold until 1960, be subsequently lost because there were no longer military aircraft in which to fit these engines. Speed may not be of paramount interest in civil transport, but for long journeys it becomes a significant consideration if it can be achieved at no major sacrifice in cost. The consensus of opinion is that at least for the time being there is room for both the jet engine and the propeller turbine, depending on the application, but there is a popular prejudice in favour of the "jet." Indeed one American company uses the word in connection with its service of piston-engine aircraft on the fragile pretext that it makes use of jet air streams found at times over the North Atlantic. It is worth also emphasising that the only propeller-turbine civil aircraft in regular service to-day are British—the Rolls-Royce Dart powered Vickers Viscount and the Bristol Britannia.

GOVERNMENT AS BANKER

A further point of view is that the Government, which has long played the combined role of "fairy godmother and merchant banker" to the aircraft industry, should at least continue in its second function. In addition to development contracts on a cost-plus basis, there have already been Government-sponsored production contracts where a proportion of the return on overseas sales is returned to the Government. Might not this principle be extended? The problem in the case of home sales is that virtually all the customers are Government bodies.

Another complaint is that the Government do not support the aircraft industry by their present distribution of orders. During peak periods of the war, the Government encouraged industry to develop considerable capacity outside the plants of the main aircraft companies. These new factories did not carry design and development teams so that they operated and still operate on minimum overheads. They are naturally very competitive and in bidding for Government production contracts are frequently successful. By being prepared to pay a little more, the Government could help finance the development team on which a healthy aircraft industry depends.

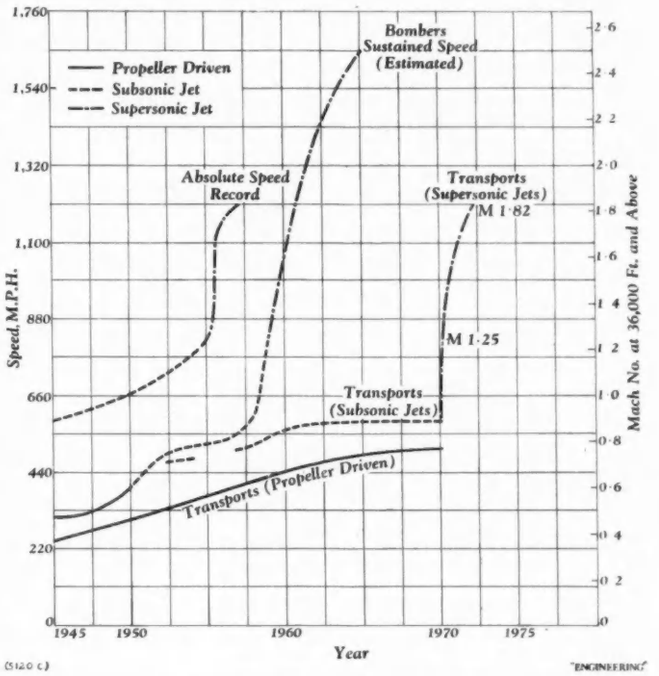
A point made by Mr. E. C. Bowyer, director of the Society of British Aircraft Constructors, is that the aircraft industry's basic research has almost universal application. From its laboratories have come advances in the study of kinetic heating, heat-resistant materials, light alloys, radar, high-strength plastics, titanium, glass fabrics, light alloys, hydraulics and servomechanisms.

Attention is also drawn to the vast capital expenditure already disbursed in the construction of wind tunnels. Bristol, Rolls-Royce, de Havilland, English Electric and the National Gas Turbine Establishment all possess high-altitude tunnels, and other transonic or supersonic tunnels are operated by the Aircraft Research Association, a co-operative body representing several aircraft firms, by Blackburn, Short Brothers and Normalair; there are no doubt others. Guided-weapon and surviving aircraft and engine work is unlikely to employ all these facilities. There is something to be said for making maximum use of them in order to recover as far as possible their capital cost.

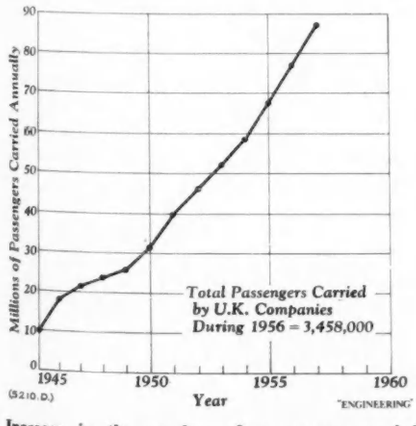
Criticism of the aircraft industry for its prodigality with public funds has been common, but it is often overlooked that the industry's participation in Britain's defence has been sought in artificial circumstances which have excluded the normal habits of commercial enterprise. Re-orientation to a commercial outlook may be arduous, but in that the Government has been largely responsible for the earlier conditions, it might reasonably be expected to give help where it is most needed.

There is a further possible prospect for the aircraft industry—one that has recently been advocated by the Duke of Edinburgh. At least two British companies are engaged in the study of ballistic missiles and no doubt in time there will be others. As an American general is reported to have said, we are on the verge of push-button war but so far we've only got the push-buttons. The more appealing and dramatic application of missile work has been amply demonstrated by the Russians and Americans. Are we to be left behind on the journey into space?

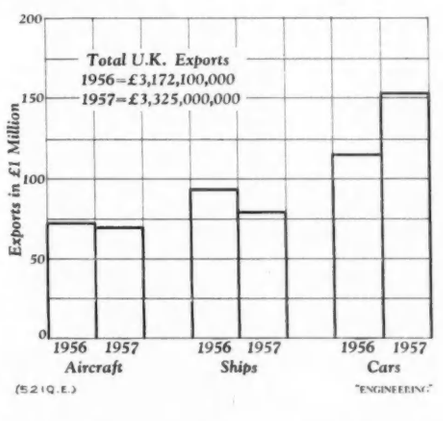
Following this discussion of the present situation and the climate of opinion in the aircraft industry, certain points are examined in greater detail.



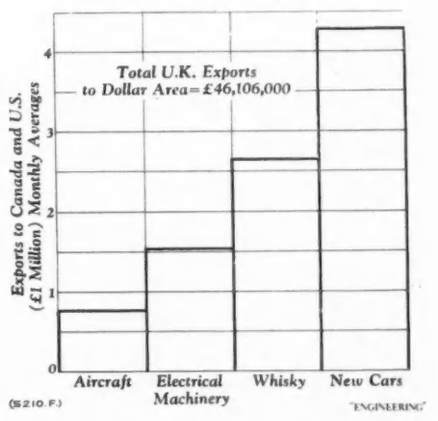
Predicted increases in the speeds of various aircraft types given by Sir George Edwards in his Presidential address to the Royal Aeronautical Society.



Increase in the number of passengers carried annually on scheduled flights excluding U.S.S.R. and China (ICAO figures).



United Kingdom exports of aircraft, ships and motor cars in 1956 and 1957.



Exports from the United Kingdom to Canada and the United States (monthly averages in 1957).

Continuing **Report of "Engineering" Inquiry**

HOW THE AIRCRAFT COMPANIES ARE RESPONDING

THE reaction of the aircraft industry to the current situation has taken various forms, which may be broadly classified under the following heading: forming groups; choosing promising military work; building civil aircraft; and diversification.

By Forming Groups

To provide financial or manufacturing viability, a number of companies are either forming groups, or setting up joint companies in which several have an interest. There are two distinct aspects of this general principle. Certain companies have been acquiring new associates and subsidiaries both in and outside the aircraft field in order to consolidate their financial strength. The Hawker Siddeley Group have diversified in this way. Based on a considerable nucleus of aircraft firms the group includes a nuclear company and other concerns with products ranging from electric generators to diesel lorries. A discussion of this form of grouping is given in the main article above.

Grouping with other firms outside the aircraft field may be undertaken for a second reason—to provide a wide range of experience for complex projects. The Fairey Aviation Company, for example, are full members of Atomic Power Constructions Limited, a consortium formed to undertake the construction of complete nuclear power stations. Similarly the Hawker Siddeley Nuclear Power Company have established a joint company with John Brown and Company Limited to advance the development of a nuclear powered ship.

The second type of grouping is a loose association of aircraft companies probably with the object of building a particular aircraft. The Government appear to be anxious to encourage this development, though it does not seem to be popular with the aircraft firms themselves. De Havilland, Fairey and Hunting Aircraft Limited have formed the Aircraft Manufacturing Company to build a short to medium range civil jet airliner, the DH121, for BEA. The Government anticipate a considerable demand for this machine and are anxious that the makers shall have sufficient capacity in plant and financial resources to cope with the orders received. It is significant that the home market is almost entirely controlled by the Government, though in choosing between the rival designs, BEA showed a notable independence.

Hunting Aircraft are themselves a member of the Hunting Group which includes shipping, aerial survey and overhaul organisations among its interests. The competing project, the Bristol 200, might have led to an association between Hawker Siddeley and Bristol, but the plans for co-operation were dropped when BEA chose the alternative machine. There is a possibility that Bristol will continue the project as a private venture, but there is no reason to believe that Hawker Siddeley will then take up the partnership. The rumour that Bristol were joining the Hawker Siddeley Group has been discounted, but there is to be technical and sales collaboration between the Bristol Engine Company and Armstrong Siddeley Motors. There are numerous other temporary or long-standing agreements or associations between aircraft companies in Britain. Vickers and Rolls-Royce, for example, have worked together for many years. Recently, too, Bristol and Shorts strengthened their association.

By Choosing Promising Military Work

Although the present crisis has been largely caused by a diminution in Ministry of Supply and Service contracts, there are still fields of military work where there is a significant demand. Indeed, it appears that if the Service chiefs had their way, manned fighter and bomber aircraft would continue to be built. Thus the Americans and Russians are showing keen interest in the manned supersonic bomber. There also appears to be room for a replacement of the Canberra multi-role reconnaisance and strike or fighter-bomber aircraft. Others are of the opinion that there will be a marked gap between the P1B and the first fully successful ground-to-air missiles. Indeed, the guided weapon is itself an aircraft. The chairman of Blackburn stated in his 1957 address: "I cannot help feeling that some manned aircraft will remain in service far longer than is sometimes imagined."

Should the planning implied by the Defence White Paper remain unchanged, the life of existing military types may be prolonged: the Handley Page Victor and the English Electric P1B, understood to be the last of their kind, would therefore continue to be made for almost an indefinite period, with sales gradually passing to smaller countries overseas. Oil-rich Venezuela appears, curiously, to be a flourishing market for military business.

Blackburn's chairman also pointed out that there would be a lasting demand for transport aircraft, helicopters, reconnaissance machines and trainers. Aircraft such as the Bristol Britannia, Blackburn Beverley, Scottish Aviation Twin Pioneer and the entire range of Westland helicopters, which have both a military and a civil application, appear to be particularly promising. In the following notes we discuss these and other aircraft likely to be retained for military roles, under the following headings: transport and freighting, strike and ground attack, light interceptor, anti-submarine and reconnaissance, target aircraft and trainers, multi-role machines, straight-up, and guided weapons. According to a disillusioned Naval pilot: "What they want is an aircraft to do 14 things badly and nothing well."

Transport and Freighting

Not only have military aircraft requirements been reduced, but also military manpower requirements—the resulting smaller force has been termed a "fire-brigade army." To be effective, fewer men must move about more quickly; transport and freight-carrying aircraft are therefore likely to remain in demand. The new mobility to be provided by Transport Command is likely to be based on such aircraft as the de Havilland Comet (Comet 1A's and 2's are already in service in Canada and the United Kingdom for this purpose), the Bristol Britannia (Short Brothers are building 20 for Transport Command), and more commodious but rather slower, the Blackburn Beverley. A successor to the Beverley, the Blackburn B107, is at the mock-up stage. For poor or limited air strips the Westland Wessex helicopter is in service and later a larger machine, the Westminster, may also be used. The Scottish Aviation Twin Pioneer is also capable of taking-off and landing in comparatively confined spaces.

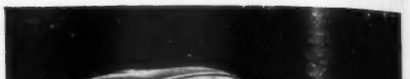
Strike and Ground Attack

Missiles, at least long-range ballistic missiles, travel in trajectories of great heights. Their approach can be detected by radar soon after launching, and their capacity to pin-point selected targets is likely to be minimal. A strike aircraft to fly at low level beneath radar screens is thus a desirable supplement to any weapon programme. For this purpose Blackburn are developing the NA39, which flew for the first time last week. The Ministry of Supply have ordered a development batch, and the United States are known to be supporting the project financially. It may serve as a replacement for certain Canberra roles, and may be adopted by the Royal Navy, Commonwealth air forces and NATO. The Hawker P1121 Mach 2 to 3 low-level strike fighter was being developed as a private venture, but its future is uncertain.

The Vickers Supermarine Scimitar, a carrier-borne fighter-bomber in service with the Navy, does not fall precisely into this field, but may be developed as a strike aircraft should the NA39 not go ahead. At present it is a large complex transonic fighter-bomber capable of carrying a tactical atomic bomb.

Light Interceptor

Although the mixed-power interceptor, the Saunders Roe SR177, has been dropped, construction of the transonic Bristol-Orpheus-powered Folland Gnat is being pursued as a private venture and the Ministry of Supply have recently ordered 14, following an Indian contract for 25, together with an agreement to build Gnats under licence in India. Though designed as an interceptor, it can also be used as a photographic reconnaissance aircraft, and a trainer version is also being built. Best prospects for such a machine appear to be in overseas countries where the potential threat is from small neighbouring countries rather than major powers and where there are tight budgets. A Mark 2 supersonic Gnat with a 6 per cent thickness chord ratio instead of 8 per cent as in the present machine, and a more advanced engine, is being developed.



Quality Cars

Anti-Submarine and Reconnaissance

Complex activities involving the subtleties of the human eye and nervous system will continue to require manned aircraft. Reconnaissance and anti-submarine work fall into this category.

Helicopters such as the Westland Whirlwind Mark 7 and subsequently the Wessex are being built under Ministry of Supply contract for anti-submarine duties and carry Sonar (dipping Asdic) equipment and an air-into-sea homing weapon. The Fairey Ultra-Light helicopter being developed as a private venture may be adopted for operation from frigates. The Fairey Gannet has also been bought in large numbers for anti-submarine service. Employing the Armstrong Siddeley Motors Double Mamba propeller-turbine, it has the following advantages. Its gas-turbine engines enable it to use kerosene fuel, safer for carrier storage than highly volatile petrol. The Double Mamba is effectively two separate engines driving two independent propellers; consequently, since the gas-turbine only runs efficiently at high speed, one engine running at rull r.p.m. can be used alone for cruising, with resulting economy and increase in range—an important factor in operation over water; the Gannet can in fact land on a carrier using one engine. Two engines are used for take-off. The gas-turbine can also be started rapidly from cold. The location of both engines in the fuselage permits wing folding close inboard and hence easy shipboard storage.

The propeller turbine is chosen since jet engines only operate economically at high altitudes and submarine spotting is necessarily low-altitude work. Certain of these advantages, which are listed as an indication of the qualities required for naval work, apply to other aircraft, including helicopters, which are normally fitted with shaft gas-turbine engines.

The Canadair C128 Argus is a modified version of the Bristol Britannia designed for marine reconnaissance and anti-submarine operations, with radar fitted in the nose and tail. The Proteus propeller turbines have been replaced by piston engines to give low fuel consumption; it can remain in the air for over 30 hours.

Targets and Trainers

Reference has already been made to the Folland Gnat Trainer, which is to be built under licence by Valmet in Finland. As long as there are manned aircraft of any kind there must be trainers. The main trainer for the Royal Air Force is the Hunting Jet Provost. F. G. Miles build the jet-powered M100 Student, a side-by-side trainer for operational jets.

Unmanned radio-controlled target aircraft are built by Short Brothers (the Canberra Drone) and by Fairey (the Firefly and the Australian designed Jindivik). The advent of guided weapons will augment rather than diminish the need for these aircraft.

Multi-Role Aircraft

There are clearly demands for military jobbing aircraft of various kinds but these machines can more conveniently be discussed under civil aircraft.

Straight Up

STOL (short take-off and land) and VTOL (vertical take-off and land) aircraft clearly have both civil and military roles and are discussed elsewhere in this

report. The problem of using small temporary airstrips in wartime is the main military consideration and several firms are working on VTOL machines. The Rolls-Royce Flying Bedstead is well known, and Short Brothers have reached an advanced stage with their jet-lift SC1, which is a genuine aircraft rather than an experimental contraption. The SC1 is fitted with a Rolls-Royce RB108 engine.

Guided Weapons

The Government have turned enthusiastically to the guided weapon, which therefore represents a profitable field for endeavour, and many firms are engaged on research, development and production in this field. The shorter-range guided-weapon is after all fundamentally an aircraft, though probably a major part of its cost is attributable to electronics.

In this field are Fairey (Fireflash air-to-air beam-rider plus a more advanced weapon), Short Brothers (SXA.5 and GPV test vehicles), Armstrong Siddeley Motors (Seaslug), Bristol (Bloodhound surface-to-air missile, also Thor ramjet), de Havilland Propellers (Firestreak air-to-air missile, with infra-red homing), English Electric (Thunderbird ground-to-air missile), Avro (stand-off bomb—to be released from an aircraft some distance from its target), and others. De Havilland also claim to make the alternator power units for 90 per cent of Britain's operational guided weapons. Rolls-Royce are to supply the power plant for Britain's first intermediate-range or intercontinental ballistic missile (IRBM or ICBM) and have a 10 year licence with North American Aviation for this purpose. De Havilland are the main contractors for this project.

Many companies are developing rocket motors, either for guided weapons or for use as boosters for aircraft: the de Havilland Engine Company (Super Sprite and Spectre), Armstrong Siddeley Motors (Snarler and Screamer), Rolls-Royce and Bristol.

By Building Civil Aircraft

The vast potential increase in the market for civil aircraft was discussed in the main introductory section of this report, though it is rumoured that there is currently a slight tailing off in passenger demand due to the recession. However, the recession in America may paradoxically be linked with a further expansion in civil-aircraft purchasing. It is suggested that the pattern of demand may change from goods to services; in other words, the public are satiated with cars and television sets and may turn to travel, say, as a relaxation. The formation of the European Common Market should also stimulate the demand for transport aircraft.

The situation in which British civil aircraft are only crumbs from the military table is clearly passing. Rolls-Royce state that the civil demand for their engines is just taking the lead from the military. The de Havilland Engine Company also announce that they are now working harder on engines for civil purpose, and Bristol, whose Proteus and Orpheus are used in civil machines, are also busy in this field. The future demand for Napier Eland and Gazelle turbo-shaft engines for helicopters and other civil applications is likely to expand rapidly. The enormous success of the Vickers Viscount shows that the civil market is not impregnable, and almost certainly Britain has a bright future in this direction. The problem of entering the civil market is discussed in a later part of this report.

Mr. B. S. Shenstone, chief engineer of BEA, points to a number of areas which show promise for civil-aircraft work, but in which there is little activity in the United Kingdom: (1) the fast jet-propelled executive aircraft as exemplified by the new Lockheed twin-engined 10 seater Jetstar; (2) the large freighter for service ten years from now; and (3) the highly developed all-metal propeller-driven aircraft for private and semi-private use. The following notes suggest other fields for civil-aircraft activity under the following headings: passenger transport, freight, short and vertical take-off and multi-purpose machines.

Passenger Transport

Air travel is still rising at the phenomenal rate of 10 per cent per annum; it is therefore a most promising arena for civil-aircraft activity.

Long Range Aircraft.—Speed is a factor of some importance where distances are great, and the jet engine is particularly suitable for high-speed flight. Moreover, the longer the flight the more convenient it is to fly at high altitudes. The very long-range transport aircraft, therefore, tends to be jet powered.

There is also considerable prestige attaching to the word "jet." Travelling at great heights, however, jet aircraft require pressurisation up to 8 or 9 lb per sq. in differential; as against 6 lb per sq. in for the Viscount. Fatigue problems are therefore more serious. It is worth pointing out that for jet aircraft it is more appropriate to calculate fuel consumption in terms of miles per gallon than gallons per hour. The de Havilland Comet 4 is a long-range aircraft, powered by four Rolls-Royce Avon jets, which flew for the first time last week. BOAC have ordered 19, and Argentine Airlines 6. BEA have ordered 6 of the medium-range variant, Comet 4B. It is significant that this aircraft can land on existing runways, whereas the large American Boeing 707 and Douglas DC8 jet airliners, which are due to come into service at the end of this year or sometime next year, will require considerably longer, stronger runways than are currently in use. Nevertheless most countries will be compelled to meet this requirement.

The Vickers VC 10 long-range jet airliner, to be fitted with rear-mounted Rolls-Royce Conway bypass jet engines and designed for service on Commonwealth (and incidentally transatlantic) routes, has passed from the project stage into the detailed design office. Its first flight is scheduled for 1961. In 1963 it will enter service with BOAC, who have ordered 35 and have a further option on 20. Passenger capacity is 108 first class. Handley Page is also considering a fast jet airliner based on their Victor bomber. There has been talk of a supersonic (Mach 2) narrow delta-wing aircraft—possibly to be undertaken by Avro of Hawker Siddeley in collaboration with Bristol. This machine might be designed for vertical take-off using 50 lightweight semi-expendable jet engines developed from the Rolls-Royce F62. Such an aircraft might take £75 million to £100 million to develop.

The long-range aircraft of the very distant future might conceivably be nuclear powered and it is understood that Saunders Roe Princess flying boats might be used as test-beds for this purpose. Although flying boats have been indicated as the ideal choice of aircraft for nuclear propulsion, Short Brothers, whose Empire flying boats did major service before the war, have said that they do not plan to return to flying-boat work—"travelling to aircraft departure points takes long enough with land-based machines."

Medium to Long Range.—The controversy of propeller-turbine versus pure jet need not be considered here, but in the medium to long range category, the propeller-turbine may be said to begin its usefulness where its economy of operation at lower altitudes starts to pay off. The Bristol Britannia with four Proteus engines has been largely successful in this field, and with the latest order for five by Northeast Airlines of America, the total sales amount to over 80 and there are a further 40 or more to build before present orders are completed. The series 310 Britannia has set up a number of records for the North Atlantic crossing, the most arduous airline route—westbound in winter for an actual journey of 3,400 miles it is necessary to carry fuel for 4,500 miles. The Commonwealth routes are also taxing, owing to temperature ranges and the high level at which many airports are located.

The next British aircraft in this category is the 86-seat Vickers Vanguard. Powered by four Rolls-Royce Tyne propeller-turbines, it is due to come into service in 1960. Designed for European and Commonwealth routes—take-off is good even at high altitudes—it has been ordered by BEA (20), and Trans-Canada Airlines (20).

The jet airliner can also operate economically over this distance and the intermediate-range Comet 4 C's have been proposed for such routes.

Short to Medium Range.—The short to medium range category is at present primarily represented by the Vickers Viscount fitted with Rolls-Royce Dart propeller-turbines. To date some 370 have been delivered or ordered and about 260 are in service. The Viscount has sold in more countries (46 airlines in 31 countries) than any other aircraft except the Douglas DC3. The Viscount is entirely civil in origin and was developed largely as a private venture. developed largely as a private venture.

New thinking is clearly represented by the short to medium range (300 to 1,000 miles) jet airliner projected for BEA. To some, a short-range jet aircraft is a contradiction in terms, though the prestige of the jet engine, its speed qualities, and the need to be first in the follow-my-leader pattern of airline purchasing may have prompted BEA to take it up. Estimated world demand for this type of machine is about 1,500 by 1966, but though some consider this a conservative figure, others point to Viscount sales as a more realistic indication. Nevertheless, demand is increasing and Viscounts have sold in competition with other machines, whereas 1,500 is given as the total world requirement.

The aircraft falling in this category is the DH121, which, though as yet no more than a brief specification, may possibly be in service by 1962. The Bristol 200 may also be pursued as a private venture, since it is argued that even a fifth of the total estimated market of 1,500 would keep a large section of the British aircraft industry occupied for several years and bring in more than £300 million. The de Havilland Comet 4B is likely to be a forerunner of these machines. Certain manufacturers believe that what will really be wanted is a Viscount replacement.

Feeder Routes.—The number of main airline terminals that a country can finance is strictly limited. To cater for shorter inter-city travel, feeder aircraft capable of operating from much shorter runways than the fast "first-line" airliners are necessary. The Handley Page Herald is designed for this purpose; a new version to be powered by Rolls-Royce Darts costs about £175,000. The Scottish Aviation Twin Pioneer, with its short take-off and landing characteristics, is a further step in this direction.

Private and Executive Aircraft.—As Mr. Shenstone has remarked, there is likely to be a growing demand for fast executive aircraft with about 10 seats. A replacement for the four-engined de Havilland Heron, two more of which have recently been ordered for the Queen's flight, might fall into this category. A light private aircraft also might find a sizeable market.

Freight Aircraft

As aircraft travel increases in scale and presumably becomes cheaper, it may become increasingly economic to carry goods by air. Perishables are obviously the beginning of this trend but the lively business carried on by Silver City Airways in ferrying vehicles and their passengers across the Channel suggest that there are far wider possibilities. Bristol set the stage soon after the war with their Bristol 170 Freighter, of which over 200 were made. The Blackburn Beverley was employed more for military purposes, but possibly its projected successor, the B.107, to be powered by the Rolls-Royce Tyne, with double speed and twice the range, will find a place in the civil field. The private-venture Armstrong Whitworth 650 Freightercoach, backed by the Hawker Siddeley group, is another competitor. A smaller simpler aircraft, the Miles HMD105 Caravan, has a slightly different role with its 1-ton load capacity (1½ to 2 tons in a later model) and easy loading facilities.

It is worth noting that the Vickers Vanguard is to be of double-bubble construction with the lower bubble set aside entirely for freight. The principle is to allow a flexibility between freight and passengers, so that where the number of passengers is small the payload can be made up with freight.

Multi-Purpose Aircraft

It has been found convenient to design aircraft with a wide range of applications—even the Vickers VC10 is described as an "omnipurpose" machine. Helicopters, which are discussed below, fall generally into this group and STOL aircraft such as the Twin Pioneer. Speed is usually no object and the word "obsolete" has very little meaning. The Westland Westminster helicopter, derived from the Sikorsky S58, is, for example, to be built in three versions: a "skyhook" which is simply a flying tubular framework for crane and other lifting or general applications; a 42-seat passenger version; and a troop carrier.

Applications of utility aircraft include: ambulance work, aerial and geophysical survey, pest control, oil and ore prospecting, power-line inspection (a Westland helicopter has been ordered for work of this kind in Japan), anti-smuggling police work (Hong Kong), farm work and Antarctic exploration.

Limited Runways

There seems to be an increasing interest in VTOL aircraft based on the rotating-wing principle, and other aircraft requiring minimum take-off space. Reference has already been made to the Scottish Aviation Twin Pioneer, which was able to use the helicopter port at last year's Paris air show. An interesting American light aircraft has a single engine, related to the de Havilland Gnome, driving four propellers, which together cover almost the whole wing length so providing full airflow immediately on start-up. Fairey build the 40 to 48 seat Rotodyne, which employs the principle of tip jet reaction for turning the rotor, and employs propellers for forward propulsion; in cruising flight, the rotor is in autorotation. A new and larger model is proposed.

Westland concentrate entirely on building helicopters, which are based on American Sikorsky aircraft and designated the Widgeon, Whirlwind, Wessex and Westminster. Bristol build the small Sycamore and the large tandem-rotor 192. Napier with their Eland and Gazelle have at present a virtual monopoly in turbines for the rotating-wing field, though the de Havilland Gnome may be fitted in some of the smaller machines—a re-engined version of the Sycamore, for example.

Continuing Report of "Engineering" Inquiry

One claim for the Rotodyne is that its rotor system is mechanically simple. It is also faster and, the makers claim, more economical than a conventional helicopter. On the other hand, it is very noisy and in city areas, where VTOL machines are likely to find their best market, this characteristic may prove a tiresome one. Helicopter rotor units are built with an ample margin for fatigue, and it can be argued that since the fatigue life is based on known fluctuating mechanical stresses, the limits are more easily calculable than with air frames where the fatigue life is conditioned by irregular buffeting stresses.

The immediate argument in favour of the civil VTOL aircraft is the saving of time it permits. In addition to the long coach journey from central London to London Airport and from Orly to Les Invalides, there are three waiting periods of possibly 20 minutes in travelling by air from London to Paris. Thus in spite of the slower speed of a helicopter, the makers claim that a Westminster should reduce what is now a three or four hour journey to two.

On the other hand, helicopters are not yet economic, in some cases costing as much as 4*s*. per ton mile as against 1*s*. for normal aircraft. The Westminster and later Rotodyne are expected to reduce this difference considerably. However, there are already services in which helicopters are operated commercially. In New York, Los Angeles and Chicago, there are helicopter services to out of town —it is argued that although a helicopter may not be competitive with a conventional aeroplane on long hauls, it beats a taxi on journeys of 10 or 11 miles on price per passenger. When Gatwick airport begins operating, inter-airport services may become profitable in Britain. Helicopter services are also employed as feeds to main airlines; Sabena are said to catch a lot of passengers that way.

By Diversification

Most familiar of all the remedies recommended to the aircraft industry is diversification, though as we have indicated in the introductory article it has its difficulties and drawbacks. Following a note on the generally abortive diversification that was carried out by many firms after the war, we examine below a number of approaches to diversification that have been taken up more recently. These approaches are: diversification within the aircraft field; buying other businesses; establishing new divisions; introducing new technical staff; purchasing licences and making agreements; and redeploying existing assets.

Post-War Ventures

Though it is some indication of current trends, the diversification carried out at the end of the last war took place under conditions markedly different from those obtaining now. For one thing, war-time employment was highly inflated and there was no difficulty in dispersing staff to peace-time industries. The main purpose appears to have been to use up stocks of materials rather than to deploy staff and capacity in an economic way. Numbers of firms built aluminium prefabricated houses and even more ambitious buildings. Bristol, for example, adopted unit construction and applied it to schools and hospitals, exporting large numbers to underdeveloped countries. Armstrong Siddeley also built houses. Besides manufacturing aluminium roof trusses, baking tins and pie-making machines, Blackburn likewise carried on a housing business, which proved so profitable owing to the degree of local demand that when prefabricated houses were no longer appreciated and light-alloy sheet was again needed for aircraft, the firm continued to build traditional houses. For this reason Blackburn established a civil-engineering division in 1956 and their Dumbarton works have recently received an £800,000 order for six 15-storey blocks of flats.

A materials surplus was also presumably the reason that Armstrong Siddeley Motors made aluminium suitcases (like Heinkel in Germany); Folland, refrigerators, filing cabinets and pony trucks; and Short Brothers and Harland, milk cans—they were the largest producers in Europe. Short Brothers also took up domestic appliances, making, for example Metaluc carpet sweepers; unfortunately they only became profitable when the company wanted to give them up. Westland's early diversification was even more fortuitous: they took over a number of small firms that happend to be their tenants—light machines and lactories, sash cords and a patent balance window, though the manufacture of hangars and an up-and-over garage door was probably once more a matter of redundant materials. Fairey and F. G. Miles are among the companies that have persisted in their pre- and post-war diversification and profited from it.

Aircraft Ancillaries and Services

Certain companies have diversified within the airfield field, making ancillary items and components associated with aircraft or performing services connected with aeronautics in some way. De Havilland Aircraft, for example, have produced an aircraft chair on the grounds that proprietary models are too heavy, but since the saving in weight is marginal—3 or 4 lb—with respect to the increase in cost the chair is unlikely to find application in other fields such as long-distance coaches. De Havilland Propellers make cold-air units for aircraft, which might conceivably be adapted for air-conditioning purposes elsewhere; Normalair, associated with Westland, make pressure equipment for high-flying aircraft; Bristol, de Havilland Propellers, Miles Structural Plastics and other companies make various plastic items connected with aircraft, from radar scanners to drop tanks. Miles Electronics make a centralised warning panel for aircraft (Fairey Gannet), designed to detect and indicate the occurence of faults. It is intended initially for training but subsequently for operational flying, and may later be adapted for railway safety and other purposes. They also make aircraft simulators, both for cockpit training and for investigating flight characteristics; at present they are building simulators for Bomber Command reflecting all three V-bombers and a Sea Vixen simulator, the MET/4, for the Navy. Ejection seats are made by Martin Baker, and also by Folland under licence from Saab of Sweden. Fairey assemble envelope tooling for aircraft and may do so for the DH121.

Services performed by aircraft companies include aerial surveying and airport operation. The Meridian Aerial Survey Company associated with F. G. Miles have carried out most of the survey work for the Southern Region of British Railways and for over 30 United States Air Force Bases. Fairey Air Surveys Limited have recently completed an aerial survey in Burma covering 200,000 square miles; the contract was valued at £200,000. Both Miles and Scottish Aviation operate services at airports, respectively Shoreham and Prestwick. Scottish Aviation also have a subsidiary, Scottish Airlines Limited, and run the airport hotel.

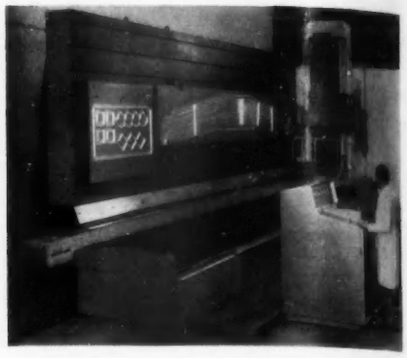
Buying Other Businesses

Diversification by securing control of other businesses has already been discussed at length in earlier parts of the report, but a few further points may be added here. It is a prime example of diversification by addition—rather than adaption. Blackburn and General Aircraft, for example, control Jowett Cars Limited, which is now mainly a spares and overhaul business; Thomas Green and Son, Limited, which is mostly concerned with mowers, rollers and agricultural equipment; Universal Flying Services Limited, and Megator Pumps and Compressors Limited, which produce pumps designed not to sieze up when the fluid pumped runs dry, having applications in coal mining and the paint, beer and wine industries.

The Hawker Siddeley Group appears to have bought companies largely on the basis of financial expediency—the group was over-capitalised and organisations, such as Brush, whose capital resources were considered to be inadequate, have been taken up. Generally, however, acquisitions have followed the general theme of power and propulsion, though the Dominion Steel and Coal Corporation Limited, of Canada, in which Hawker Siddeley have recently acquired a 76 per cent interest, is only indirectly connected with this field. A spokesman for the company was of the opinion that the time had come to take a breather in order to consolidate. Aircraft now only account for 30 per cent of turnover as against a former 85 per cent. A new link between the engine interests of Bristol and Armstrong Siddeley was announced last week.

In groups of this kind—formed mainly to afford financial resilience, or "rolling power"—the member companies are essentially autonomous and self-supporting, with their own sales organisations and policies, but with a common chairman or board of directors to give cohesion. The problem, presumably, is to find the degree of control yielding optimum returns.

Another motive for purchasing other firms is simply in order to increase capacity. Rolls-Royce bought Sentinel (Shrewsbury) Limited in 1956 to augment shop-floor space for its oil-engine division; while Westland secured Western Airways to provide drawing office accommodation. A final explanation of the predatory urge is the need to assemble experience for new ventures. Thus English Electric obtained control of Marconi, an electronics company, and Napier, an engine company, with this object. Napier make not only the Eland and Gazelle series



Advanced Machine Tools

of shaft-turbine engines for aircraft but also the Deltic engine for diesel locomotives. In view of the dominating part played by electronics in guided weapons and in aircraft—nearly 50 per cent of the income on aircraft sales goes to the electronics industry—an electronics organisation is a natural ancillary for any aircraft company. Finally, de Havilland bought some nearby farms during the war, though it appears that farming has not become one of the company's major activities.

Establishing New Divisions and Companies

Instead of acquiring new subsidiaries, a company may form divisions within its own structure as an amoeba does before reproducing. In many cases, these divisions eventually become companies—Bristol, Fairey and F. G. Miles illustrate this trend. Thus the Miles electronics division formed in 1956 became a separate company in 1957 and Bristol Aircraft Limited was once a division of the Bristol Aeroplane Company, which remains the holding company. Normalair, too, started life as a division of Westland to provide altitude pressurising equipment for the company's high flying Welkin aircraft. De Havilland built Rogerstone forge in 1940 but in this case the need subsequently disappeared and the company relinquished it after the war. It remains to be seen how many existing divisions become companies—Parkinson's Law perhaps? A valid reason for forming new companies arises from certain trade-union practices prevalent in the aircraft industry and is discussed under the heading diversification problems below. Nevertheless it is clearly possible for the divisions of a company to operate effectively without separate registration as companies. The Rolls-Royce Oil Engine and Motor Car Division illustrate this point.

Introducing New Technical Staff

Associated with the formation of new divisions is the introduction of additional specialist staff. Thus Rolls-Royce recruited specialists for its nuclear and rocket departments. Fairey, who entered the nuclear and missile field at an early stage, emphasise that knowledge of these subjects was so scanty at the time that the only possible approach was to engage qualified men and start from scratch.

Licences and Agreements

When a company is called upon to diversify or change its products at short notice, it cannot expect to compete immediately in fields where the existing producers are of long standing. It may therefore be desirable to "buy time," involving the purchase of manufacturing licences. It may also be necessary to subsidise initial entry into the new market. Tried products are the only ones likely to yield an immediate return. Thus it is known that Armstrong Siddeley Motors have concluded at least one licence agreement with a Continental firm of heavy diesel-engine manufacturers, and have been studying for some time plans for making diesel engines for all kinds of transport. Propulsion generally is likely to provide the arena for the bulk of Armstrong Siddeley Motors' diversification. Armstrong Siddeley also hold a licence from the AiResearch Manufacturing Division of the Garrett Corporation, U.S.A., for making auxiliary power gas-turbines and air turbine starters. Blackburn hold similar licences from Turbomeca of France for a range of small gas-turbines (shaft and jet) which they adapt not only to aircraft propulsion but also for driving compressors and auxiliary power units.

Westland hold licences for the building of Sikorsky helicopters, the de Havilland Engine Company for

the American General Electric Company's T58 turbo-shaft engine, the British version of which is called the Gnome. De Havilland Propellers make a constant-speed propeller unit and their air-conditioning plant under licence from the American firm of Hamilton Standard. It should be emphasised that almost invariably considerable development work is carried out on the licensed product to adopt it to the special conditions and applications chosen by the licensee. English Electric have secured for their guided weapon work and the peaceful application of its principles a licence from Minneapolis-Honeywell for gyroscopic equipment. Agreements for the exchange of information are also common. Fairey Aeroplastics and the United States Polymeric Corporation have an association of this kind.

Redeploying Existing Assets

Diversification in its most complex sense involves the redeployment of a wide range of assets, not merely financial resources. Such assets may include special experience, plant, or factory space. Typical resources are briefly discussed below. One factor not mentioned is location. Saunders-Roe, who are close to the sea, build boats (that is how the firm started), and the persistent local demand for housing has almost certainly conditioned Blackburn's manufacturing policy. Short Brothers undertook to erect street-lighting in Belfast.

Experience and Skill.—Examples of the redeployment of skill and experience are as follows: development of variable-pitch fans for cooling installations and components for wind-driven generating plant by de Havilland Propellers; the application of vibration techniques evolved for propeller testing to motor-car production by the same company; design of a new gearbox for the adopted B.M.W. car by Bristol, whose detailed knowledge of gearing stems from the manufacture of reduction gears for aero-engines; construction of advanced forms of milling machines by Short, Fairey, Blackburn, and other companies on the basis of precision mechanical-engineering knowledge; nuclear research by Rolls-Royce, de Havilland, Hawker Siddeley and Fairey using fundamental scientific and technical skill; the interest of several firms in reactor simulators arising from their work on analogue computers for aircraft applications; production of resonance spectrometers and other analytical instruments by Fairey, employing experience of guided weapons and electronic equipment; and the consideration of inertial guidance systems to underwater tankers, submarines and aircraft as a result of studies carried out by English Electric.

Fairey are also interested in heat exchangers for use in all kinds of plant. The industry has wide experience in plastics (Bristol, de Havilland Propellers and others); electronics and control systems (Saunders-Roe, F. C. Miles and Blackburn); and precision engineering (Short Brothers and Harland have a precision-engineering division). Indeed, most aircraft firms are prepared to undertake creative engineering of one kind or another.

Tools and Equipment.—Aircraft companies are generally equipped with large general machine shops and a considerable number of special-purpose tools, including Hufford stretch presses, rubber die presses (Westland made 3,000 doors for Ford Anglias using these machines), contour and skin millers, Cramic surface milling machines (Vickers-Armstrongs), large-diameter lathes for internal grooves (engine companies), chemical milling equipment (several companies), drills, riveters, broaches (engine companies for fir-tree roots), and jig borers. De Havilland Propellers have a three-dimensional Berliner camfollower machine for cutting aluminium propeller blades. Firms frequently build their own tools. Blackburn designed and built a special skin miller for their NA39 strike aircraft in 12 months, and Fairey offers for sale a three-dimensional electronically controlled miller designed and built by them in collaboration with Ferranti. Precision foundries using the lost-wax process and light-alloy foundries generally are common, but Fairey make in addition investment moulded steel castings—the first to gain Ministry of Supply approval. Fairey also undertake three-dimensional lofting—envelope tooling—on a sub-contract basis.

Besides precision machining capacity, there is a variety of special equipment. For example, Short Brothers and Harland have fatigue testing machines ranging from 50 lb to 100 tons. The Ferranti Manchester computer used by Armstrong Siddeley Motors for gas-turbine engine design calculation could be adapted for determining volumetric efficiency of diesel engines, or, by providing a larger memory, for commercial work. Saunders-Roe's experimental tanks are employed not only for aircraft ditching tests, but also for ship and submarine investigations.

Materials.—Though materials knowledge and technique should strictly be classified under experience or possibly tools and equipment, the use of uncommon materials is so widely characteristic of the aircraft industry that the subject requires a special place. We have already indicated how after the war redundant stocks of light-alloy sheet led to the aircraft industry's entry into house construction. Similarly the application of plastics to aircraft work led to the growth of a lively plastics subcontracting business.

The use of a plastics filling for hollow propellers gave rise to a plastics department at de Havilland Propellers, and Bristol, who make all the plastics trunking and cabin equipment for their Britannia, are branching into new applications and demanding materials with improved properties from the chemical industry. At present they are only prepared to undertake complex items required in comparatively small numbers since they have not the capacity for long production runs, but their plastics departments are extremely active.

Like Bristol and de Havilland, F. G. Miles have considerable experience with glass cloth and Durestos (resin-impregnated asbestos felt), and their subsidiary company, Miles Structural Plastics Limited, also make a virtually unbreakable translucent roofing material known as Milite. Based on glass fibre, it is prepared in a number of colours and can be screwed or sawn. Glass cloth and Durestos can be used in making containers for life rafts, tanks for pickling, plating and anodising (F. G. Miles), pontoons for bridges and other items. These materials are lighter than wood and not subject to corrosion. Laminated materials and plastics are the basic products of Saro Laminated Wood Products, whose work ranges from ships' decks and small boats to "panelling in pubs."

The welding and general working of Nimonic and other special alloys may also indicate new fields of interest. Light alloys have applications far beyond the aircraft industry. Experience in machining materials of this kind probably led to Fairey's long-standing contract for machining the fuel-element cans for United Kingdom Atomic Energy Authority nuclear plants. English Electric are prepared to handle subcontract work on titanium, a material originally investigated mainly for aircraft work.

Production Capacity.—Factory space in the aircraft industry is abundant, since aircraft themselves and their components are often large. This raises major problems in converting to other products since roofs are high and power overheads for heating and lighting considerable. General machine shops, however, are similar to those elsewhere and Vickers Supermarine, for example, are prepared to sublet their ultra-precision machining capacity.

Products.—The products of many companies, though designed for aircraft purposes may be applied or adapted to other uses. Vibration equipment built for testing their own products by de Havilland have been employed for locating the rattle in motor-cars and getting the bubbles out of Cadbury's milk chocolate. Their cold-air unit might well have air-conditioning applications at sea level as well as in the air, though at present it is designed to operate in conjunction with aero-engines, and their range of alternators designed for guided weapons may well find commercial uses.

Bristol have adapted their Proteus engine to propel a fast patrol boat, and its application to other forms of propulsion is a reasonable prospect, having the usual virtues of aircraft gas-turbines—high performance, lightness, compactness, long life, and simplicity, though a somewhat higher fuel consumption than a diesel engine. Armstrong Siddeley Motors and Blackburn are both studying the auxiliary and industrial applications of their smaller engines, which may be used in conjunction with fire pumps, air compressors or generators. It is significant that the Rolls-Royce Tyne, though a much larger propeller-turbine, employing some jet effect and built strictly for aircraft, is said to have a lower fuel consumption

NEW PRODUCTS

Products other than aircraft made by the companies included in this inquiry are listed below under the following headings: agriculture, aircraft ancillaries, atomic energy, building and civil engineering, electronics and servo-mechanisms, instruments and electrical, materials, mechanical and precision engineering, plastics, services and transport. It should be emphasised that the list is not intended to be comprehensive but merely a guide to the kind of work aircraft firms are at present tackling.

Companies concerned are indicated by abbreviations as follows:

Armstrong Siddeley Motors Limited (AS),
Blackburn and General Aircraft Limited (Bl),
Boulton Paul Limited (BP),
Bristol Aeroplane Company, Limited (B),
de Havilland Holdings Limited (DH),
English Electric Company, Limited (EE),
Fairey Aviation Company, Limited (Fy),
Hawker Siddeley Group (HS,)
Folland Aircraft Limited (Fo),
F. G. Miles Limited (M),
Rolls-Royce Limited (RR),
Short Brothers and Harland Limited (S),
Scottish Aviation Limited (SA),
Saunders-Roe Limited (SR),
Westland Aircraft Limited (W).

Agriculture

Lawn mowers and rollers (Bl)
Light agricultural machinery (Bl)
Milk cans (S)
Cabs for Ferguson and Fordson tractors (SA)
Lactories (W)

Aircraft Ancillaries

Turbo-starters and other ancillaries (Bl)
Aircraft chair (DH)
Undercarriages (DH)
Radar scanner (DH)
Cold-air units (DH)
Stackable fuel tanks (M)
Cockpit procedure trainers (M)
Flight simulators (M)
Ejection seats (M, B, Fo)
HTP refueller (SR)
Bomb carrier (SR)
Aero-radar aerial (B, M)

Atomic Energy

Mobile nuclear reactors (DH)
Nuclear propulsion (RR)
Nuclear marine propulsion (HS)
Fuel element cans (Fy)
Reactor charge and discharge equipment (Fy)
Fume cabinets for nuclear work (SR)

Building and Civil Engineering

Aluminium roof trusses (Bl, B)
Prefabricated and traditional housing (Bl)
Street lamps (S)
Plumbing units (SA)
Wood panelling (SR)
Huts (SR)
Garage doors and windows (W)

Electronics and Servo-Mechanisms

Analogue computers (Bl, Fy, M, S)
Control engineering (BP, Fy, S)
Miniaturised electronics components (EE)
Inertial guidance systems (EE)
Control engineering (Fy)
Centralised warning panel (M)
Computers (SR, S)

Instruments and Electrical

Vibration equipment (DH)
Strain gauges (DH, SR)
Small alternators (DH)
Safety ohmmeter (Fy)
Low-frequency vibration-measuring equipment (Fy)
Two-mode vibrating tube (Fy)
Recording and measuring equipment (Fy)
Displacement pick-up (Fy)
Nuclear magnetic resonance spectrometer (Fy)
Process control (Fy)

Materials

Welding heat-resisting steels (B)
Titanium handling (EE)
Investment moulded steel castings (Fy)
Aluminium castings (RR)

Mechanical and Precision Engineering

Car gear-box design (B)
Marine gas turbine (B)
Pumps (Bl)
Air conditioning plant (DH)
Cooling fans (DH)
Blades for wind power plant (DH)
Extractor fans (DH)
Heating, ventilating and hydraulic engineering (DH)
High-duty pump (DH)
Machine tools (Fy Bl)
Envelope tooling (Fy)
Three-dimensional profile miller (Fy)
Heat exchangers (Fy)
Anti-vibration mountings (Fy)
Precision tools (M)
Jigging (M)
Chemical milling (M)
Vacuum furnace (M)
Torque converter (RR)
Diesel engines (RR, AS)
Precision engineering (S, BP)
Carpet sweepers and domestic appliances (S)
Industrial hydraulics (S)
Rotary dispenser (SR)
Pressurising equipment (W)
Breathing equipment (W)

Plastics

Standard tanks (B)
Drop tanks (B)
Gas storage vessels (B)
Radomes (B)
Nose cones (B)
Trunking (B)
Radar scanners (DH, B)
Domestic items (Fy)
Pontoons (M)
Translucent roofing (M)
Containers for inflatable life rafts (M)
Commercial containers (M)
Tanks for chemical processing (M)
Boxes (SR)
Glass fibre products
Durestos products
Polyester resins
Perspex
PVC

Services

Hire of computer time (AS, S)
Aerial surveys (Fy, M)
Geophysical surveys (Fy)
Airport services (M, SA)
Hydrodynamic test tanks (SR)

Transport

Motor cars (AS, B, RR)
Marine-decking, sailing boats (Bl)
Car spares (Bl)
Hot moulded racing dinghys and utility boats (Fy)
Sheet metal forming for motor industry (S)
Caravans (SA)
Touring coaches and buses (SA, SR)
Marine-hydrofoil boats, fast patrol boats (SR)

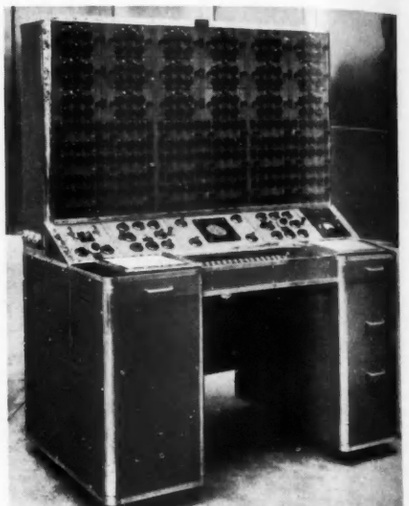
Continuing Report of "Engineering" Inquiry

(0·388 lb per e.h.p. per hour at typical cruise) than a modern piston engine and may indicate a new expansion in gas-turbine applications generally.

Electronic equipment is particularly versatile. Analogue computers for aircraft simulation made by Miles Electronics are built up from a series of standard off-the-shelf units and may conceivably be used for simulating nuclear-reactor kinetics. A resistance-measuring unit employing a photo-electric principle was designed by Fairey for testing guided weapons, but its no-current safety qualities make it suitable for use wherever there are explosive or inflammable materials. Strain gauges made by Saunders Roe and the inertial guidance system being developed by English Electric have had far wider applications than those for which they were originally intended.

Labour.—To keep present staff fully employed is one of the principal reasons that certain companies have undertaken diversification. Indeed, it has been said that the motor-car divisions of aircraft and engine companies are unprofitable businesses, but are kept in existence as a pool for skilled labour.

Occupying design and technical staff is a further problem, and in the long run new products undertaken are likely to be those requiring some development effort. The policy of the English Electric Company is that all engineers shall be so trained that they can be transferred from one division of the group to another without acute problems of readjustment.



Analogue Computers

MAKING THE CHANGEOVER

In making the adjustment to a new product policy, there are bound to be many problems, a few of which will be entirely unfamiliar. Some of the factors involved in making a changeover are considered below under the following headings: work in hand; reorientation; problems in converting to civil-aircraft production; selling civil aircraft; and problems of diversification.

Work in Hand

Government military orders have in general been cut off abruptly, and in some cases a changeover to a new product policy has had to be made at very short notice. It is therefore desirable to ascertain what is the industry's margin of safety—how long will current work and orders provide a breathing space while the new policies are formulated and put into operation? In general, present contracts and orders may keep the industry active for two or three years, though not necessarily healthy, and in some cases the margin is as little as six months. But it should be borne in mind that orders are still coming in for Viscounts, Britannias, Twin Pioneers, Gnats, Sea Vixens, Canberras, P1B's, Victors, Scimitars, and other military and civil aircraft, while there are still outstanding orders for Hunters, Javelins and several more.

A firm that has been almost exclusively devoted to manned fighter work, Vickers Supermarine, have work to last at least two years, though in order to centralise production it has been necessary to close a number of outlying factories. English Electric believe that the "stretch" on the P1B is of the order of 10 years. In the engine field, Armstrong Siddeley Motors state that it will take at least three years for aero-engine work to run down to its new level, and the de Havilland Engine Company indicate that they too have production work for a minimum of three years.

Another method of saving time, as has already been noted, is to purchase manufacturing licences, but even here there is a delay period before a product can be marketed profitably. Income from licences sold to other concerns is another interim standby—SNECMA in France, for example, are still making the Bristol piston engine Hercules. Certain companies also carry out extensive overhaul and maintenance work, which will presumably continue for some time yet; Fairey anticipate servicing work for the next five years at least.

Reorientation

All industrial development is tending towards higher proportions of skilled and qualified staff, but this is particularly true of the aircraft industry where products are becoming increasingly complex and involving more and more electronics. Most firms believe that there will be some contraction in labour force, though perhaps not an extensive one. Changing plant requirements are clearly another factor; it was pointed out during this inquiry that a lot of capital plant is not used already.

Taking up new work may bring changes in organisation. Folland in turning over from subcontract work to producing their own aircraft had to establish a service department and to set up facilities for maintaining contacts with overseas customers. When Westland decided to concentrate on helicopters they had the problem of assimilating their fixed-wing aircraft staff and management. Sometimes it is the problem of introducing new management staff rather than finding places for those made redundant. As a spokesman for the Hawker Siddeley Group observed, readjustment of this kind is very much a matter of personalities. But in the words of another representative of the group—this time from Armstrong Siddeley Motors—"We have turned in a few years from piston engines to gas-turbines, from gas-turbines to rockets, without any previous knowledge of these subjects. We adapted then; we can adapt again."

Converting to Civil Aircraft Production

Based as it has been on military aircraft, the aircraft industry faces an extremely difficult task of converting at least partially to civil-aircraft production. The procedures for working in the two fields are in many cases quite different.

Military orders have previously been in the region of hundreds of aircraft, whereas civil orders are frequently only for a few score. Each military type must show a marked improvement on its predecessor while civil machines undergo a more gradual evolution. For each new military aircraft the system components are redesigned; for civil aircraft this approach must be unlearned. Indeed sophistication for its own sake is eschewed. Yet civil aircraft have almost invariably been built on the basis of military development work, which has served to write off a substantial part of the initial cost of the civil machine. The Americans still have this advantage in that 90 per cent of their aircraft work is still military, while in Britain the proportions are now roughly equal.

Many more spares are required for civil aircraft, since they remain in service longer and while in service are actually flying for a far greater number of hours (perhaps 8 or 11 a day), than is the case with military aircraft. Thus Rolls-Royce state that there is a drift from building engines to making spares; it is estimated that once all the Viscounts being built are in service Rolls-Royce's Derby factories could be kept busy on spares for Dart engines alone. A four-engined airliner is said to consume engine spares in its lifetime equivalent to one new engine. Spares and stock control also present new problems for the airframe makers. Vickers state that any firm wishing to enter the civil field and to keep ahead must go in for some form of mechanisation in its stock-control system, using punched cards or similar methods. The number of parts in stock for sustaining Viscount and Vanguard production and held for aircraft in service amount to 250,000. The figure is increasing and within two years is expected to be about 400,000.

There are a number of special requirements for civil engines. Rolls-Royce have been called upon to study thrust braking and the silencing of jet noise, for which they have an information-exchange agreement with Boeing. The new Comets will be the first aircraft to have silenced engines.

Finally, there is the problem of a new outlook. There are likely to be more private ventures, and those with some experience of this approach are likely to have an advantage. Collaboration will be between the aircraft firm and a large number of airline operators and not simply with a Government department. Standards of airworthiness will be maintained in accordance with the Air Registration Board's publication *British Civil Airworthiness Requirements*, or in the case of the Netherlands and the United States with Civil Aeronautics Administration requirements, not by Air Inspection Directorate officials in accordance with *Air Publication* 970. Aircraft must be tailor-made to a wide range of differing customer requirements, and it is important to have the right aircraft ready at the right time. Approach to sales will also require new procedures, and this is discussed in a separate section below.

Selling Civil Aircraft

Selling aircraft in the civil market involves a unique approach. The following notes are based largely on the remarks of a representative of Vickers-Armstrongs (Aircraft) Limited. Their 10 years of selling civil aircraft has given them a special knowledge of its peculiar problems.

High-pressure selling is essential, since the break-even point for a large passenger aircraft may be as many as a 100 aircraft sales; the figure given for the VC 10 is 70 or 80, but as a project advances the break-even number tends to increase. A smaller aircraft, of course, may break even after fewer sales, and the Handley Page Herald, costing £175,000, will recover its development costs after the first 16 production models are sold. A Viscount costs £400,000 and the price of a Vanguard is likely to be over £800,000. It is nowadays impossible to produce large aircraft in advance of orders. Vickers emphasise that an aircraft can be sold almost on its engines alone, so that an airframe manufacturer must be prepared to adopt the engines his customer prefers. What is more, few airlines will buy a large aircraft before they have experience of a smaller aircraft made by the same company.

The first sale of an aircraft type is a critical step and for this initial breakthrough the price is made as competitive as possible. Usually the first sale is on the home market and in Britain there are virtually only two customers, both being Government concerns. A sound home market is fundamental to successful exports. It is essential to keep to target dates, since even a small delay may be very costly to the operator. Moreover, the lead time between the placing of an order and delivery must be kept as small as possible, and for this reason even the first aircraft may be built on the production jigs. It also follows that available capacity must be considerable.

Willingness to meet customers' individual requirements is fundamental, and Vickers do so partly by stocking a wide range of standard off-the-shelf optional extras, and partly by a readiness to depart from normal practice when such departures are called for. Bristol, too, are prepared to fall in with special requirements: a recent sale of Britannias to an American airline depended on incorporating various modifications to conform with differing American airworthiness requirements; the changes were promptly made. An additional fitting, say self-lowering steps which necessitate automatic braking of the inboard propellers, will involve a price and weight penalty and the customer is immediately informed of these figures. Workshop overhaul equipment has been geared to American practices where necessary and after-sales service has been maintained at a high

level. Close collaboration with the airlines is essential in preparing a new design, and subsequently co-operative advertising can be very profitable—"Will passengers for Viscount flight number . . ." Advantage can also be taken of the desire by airlines to keep up with the Jones. Thus sale of a new version of a machine may set off a fresh round of buying. Production of Viscounts is still at the rate of 120 a year, and sales of this "potboiler" provide an invaluable cover while the Vanguard and VC 10 are in preparation.

A particular approach to the civil market adopted by Vickers has been the formation of a Civil Aircraft Development Group. Vickers have considered it of paramount importance to find out "how the customer ticks," and the CADG, whose function is broadly technical sales, has been set up with this in view.

It is a branch of the design organisation and has many roles, one of which is to ensure the continuity of good features in design and to discard the bad. It forms the main technical liaison link between the firm and a potential customer before the contract is signed. The group also performs detailed analyses of customers' routes to determine how Vickers aircraft will perform under their conditions. In any investigation of an airline operator's route pattern, the group checks the nature of his present equipment, load factors, the time to complete a leg, and what he thinks about re-equipment. Realistic studies are carried out, based on representative temperatures and altitudes, operation under the most adverse conditions, and available airport services; and computers are used to evaluate the information. When complete, a full report is presented to the operator whether or not he intends to buy. Rolls-Royce perform similar studies of all aircraft built, in order to assess the possibility of fitting Rolls-Royce engines; this is particularly profitable where American aircraft are purchased by European air forces or airlines, which are frequently anxious to save dollars.

Breaking into the United States dominated market is extremely difficult—America meets 85 per cent of world aircraft demand. Douglas, who are not too shy to claim to be "the only civil aircraft builder who can tell the customer what he wants," are responsible for half this figure. Civil aircraft production and sales make a special demand on financial resources. Not only does the company have to finance the development of its own aircraft, but it has to be prepared to give credit on sales. America has a competitive advantage here, since commercial loans are more easily raised in the United States. Provision of maintenance facilities in America is obviously easier for American manufacturers and there is naturally a tendency for Americans to buy American products. Nevertheless, Viscounts and Britannias have both been sold to United States operators. Elsewhere, British companies have the advantage that their products can be bought for sterling.

Diversification Problems

Basically, diversification is a management problem, at least initially. The Hawker Siddeley Group, for example, recognised that they must increase their managerial strength to cope with their new complex of companies; "they have got them, now they must learn to run them."

The group has never been top heavy and means must be discovered of achieving at least a degree of technical integration. With this in view, Sir Arnold Hall has been appointed group technical director and represents the nucleus of an overall planning authority. Fairey have also undergone management changes as a result of diversification. Eighteen months ago a technical director was appointed with two special chief engineers, one responsible for aircraft work, the other for instruments, electronics and guided weapons. The technical director is not concerned with day-to-day decisions but with long-term planning. Rolls-Royce has an Advance Planning Group, which is charged to "keep in touch with scientific advances and to investigate their applicability to Rolls-Royce, either in the improvement of existing products or the development of new ones."

Apparently, Hawker Siddeley have so far no central market research unit, which would appear to be desirable in view of the group's enormously diverse potentialities. Indeed, apart from the normal work of sales departments, which are generally highly specialised, no aircraft company seems to have undertaken systematic market research, though certain firms have begun to establish small teams for this purpose. Possibly the main problem for a sales department is the changeover from selling to a few customers to selling to a crowd.

Another management problem concerns the redeployment of labour. As in shipyards, the trade unions in the aircraft industry have established certain practices, which are unlikely to prove economically tolerable in the manufacture of commercial products. For this reason it may be desirable to operate independent companies, taking on staff under new contract agreements.

Diversification is bound to cost money. Mr. Eric Turner, chairman of Blackburn, in his address at the company's last annual general meeting, referred to "the increasing sums which have necessarily been retained in the business to finance the growth and diversification of our activities." At their last annual general meeting, Bristol were given permission to double their capital. At present, however, the economic climate is not favourable for large-scale capital re-equipment, though the process of diversification is likely to be continued over a period of several years.

Many of the problems involved in entering new fields have been considered in earlier sections of the report, but few facing the industry are more intractable than those arising from the high level of its skill and the high quality of its normal products. There seems almost to be only one real solution: that the aircraft industry should continue making aircraft.

A COMMENT ON AERO-ENGINES

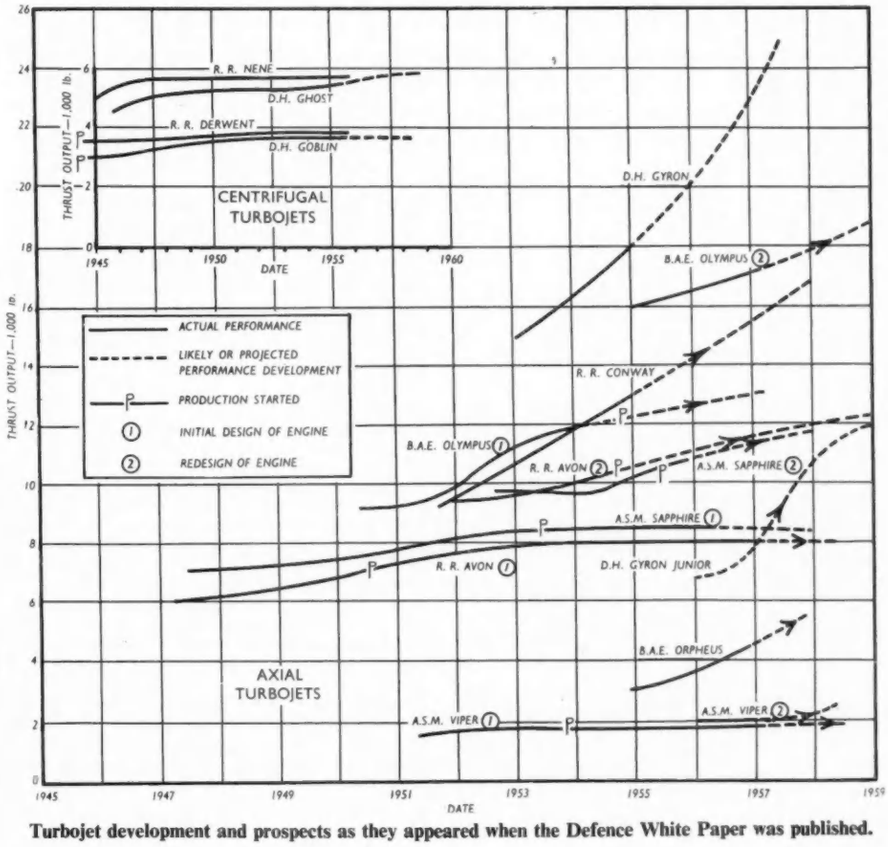
There are some seven companies building aero-engines in this country—Alvis, Armstrong Siddeley Motors, Bristol Aero-Engines, Blackburn, the de Havilland Engine Company, D. Napier and Son, and Rolls-Royce. It would appear that certain of these will be affected by the situation, if not all, and since engines represent a very special aspect of aircraft production it is appropriate to discuss them separately. British engines are of course fitted in both British and foreign aircraft—certain versions of the Boeing 707 are to have Rolls-Royce Conways. Vickers point out that aircraft are often sold on the reputation of their engines. Before engines are accepted, and even subsequently, they undergo long and expensive development. However, the fundamental question with which we are concerned here is: how can the British aero-engine industry retain the lead it holds at present throughout the world? The position at the date of publication of the Defence White Paper, for both shaft and jet turbines, is indicated by the illustrations on this and the following page.

Background

Apart from a few special examples, aero-engines have been developed with the aid of Government money. It remains to be seen whether many engines can be brought successfully to the operational stage without this assistance. Already the de Havilland Engine Company has discontinued work on the Gyron, though a smaller version, the Gyron Junior, is to go ahead. Bristol have been compelled to abandon the Orion, a novel propeller-turbine project, and the Armstrong Siddeley supersonic engine has also been dropped. The Rolls-Royce by-pass projects beginning with the Conway are very promising, but by no means cover the whole field of aircraft requirements. Rolls-Royce engines, like those of de Havilland and Bristol, do in fact extend over a wide range of demands in both propeller-turbine and jet fields; the Gyron and Gyron Junior with and without reheat range from 7,000 to 30,000 lb thrust. But advanced engines for high-altitude operation at supersonic speeds appear to be under development by no one—apart from rocket (de Havilland Spectre, Napier Scorpion) and ramjet (Bristol Thor) devices, which are only of special application. Napier make shaft-turbines broadly covering the range 800 to 3,500 e.h.p.

The de Havilland Gnome based on the General Electric T58, the Turbomeca derivatives built by Blackburn, the Vipers, Mambas and projected P181 and 182 of Armstrong Siddeley, and the Gazelle series of Napier, suggest that the future of the smaller engine is more secure, presumably because it costs less to develop.

Aircraft engineering—airframe and engine—in



Turbojet development and prospects as they appeared when the Defence White Paper was published.

Continuing Report of "Engineering" Inquiry

the past ten years has so advanced in scope and complexity that the complete financing of anything but the smallest of projects is beyond the scope of the average concern in the industry. Government support therefore is supplied on this count also, with the result that the effects of normal commercial competition have become progressively more smothered. And again, because of the need to maintain the potential of the aircraft industry in case of a national emergency, some measure of balance has been struck in allotting military contracts, and for that matter, civil contracts also. This likewise has helped to lessen the consequences of participation in a technically highly competitive industry. On the other hand, it has been a general tendency that the award of production contracts of any magnitude has been to those concerns most capable (in terms of men, equipment and resources) of engineering and producing a particular aircraft or engine.

On the piston-engine side, the only high-power unit in production is the Bristol Centaurus, and the only engines still under active development are in the low power bracket—namely the Alvis and de Havilland units. It is only in the up to 1,000 h.p. bracket that any great future lies for the piston engine, and this power figure is likely to be progressively encroached upon by turbo-prop and shaft-turbine engines down to possibly the 400 to 500 h.p. range. Ultimately this will leave only the four and six-cylinder engines of the Blackburn Bombardier and de Havilland Gipsy Queen and Major series. Alvis, as the only aero-engine concern in this country yet to enter the turbine field, anticipates at least five years useful production ahead for its engines. This will involve business not only in British and foreign military markets, but also in the corresponding civil markets.

This situation, which also applies to Blackburn's and de Havilland's products, represents a more stable one as this aspect of the companies' work is not dependent on the orders of one market or customer only. And for Alvis at least the piston engine field is at present an expanding one—which is more than can be claimed for the turbine engine markets open to certain of the other manufacturers. However, although collectively amounting to a not inconsiderable outlet for the various engines, the individual markets are small and involve the drawbacks of dealing with a multiplicity of comparatively small customers when compared with the "big business" of government military contracts.

It seems fairly safe to predict that except for such ultralight engines as the 30 h.p. Rollason R.T.W., no new piston aero-engines are likely to be developed in this country. The position in some years time can be foreseen when even the present interest in piston engines will have progressively diminished to the point where the traditional piston aero-engine manufacturers will be unwilling to do anything other than produce spares for their engines.

On the turbine engine side, the first series of axial military turbojets, that is the 100 series of Armstrong Siddeley Sapphire, the Bristol Olympus and Rolls-Royce Avon, are now in service and are unlikely to see any further applications in new designs of aircraft. The same remark, it would appear, applies to the 200 series Sapphire and for the 200 series Avon, installations beyond those already known, are unlikely to be in front line roles, that is, fighters or bombers.

Contemporaneous with these three engines is the Armstrong Siddeley Viper, which is now also available in two versions. This engine, and the more modern Bristol Orpheus in the thrust bracket above it, are likely to fulfill all power plants requirements for light fighters and trainers for many years to come. The features of simplicity and reliability are important for such engines—corresponding as they do with the standards established by low-power piston engines. The de Havilland Gyron and Gyron Junior are the first British turbojets designed from the start for supersonic propulsion purposes.

Problems of Aero-Engine Manufacture

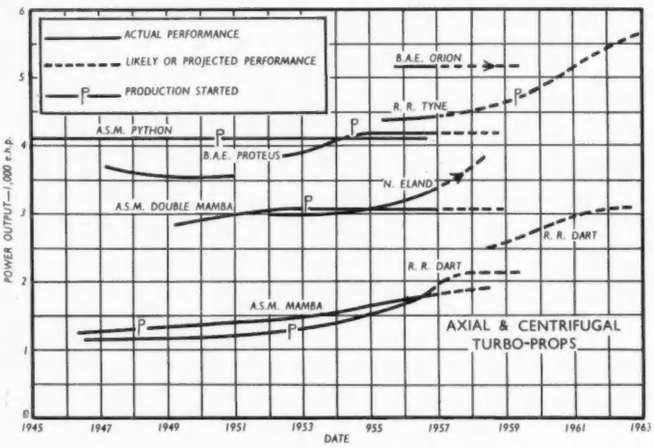
It may be useful to consider the problems that face the aero-engine manufacturer from the viewpoint of one company—Bristol Aero-Engines Limited.

There are perhaps two considerations which outweigh all others. These are the immense cost of the development of a modern aero-engine and the uncertainty of securing a sizable production order for any given engine when it has been developed. Talking in round figures, it might cost over £10 million to develop a high-thrust engine to the state of reliability necessary to offer it, for example, to a civil aircraft manufacturer for use by commercial airlines. To illustrate this point, some published figures on the Bristol Olympus turbojet may be quoted, the latest version of which, the 16,000 lb thrust Olympus Mk. 200, was type tested in January, 1957, and will equip the Vulcan 2 bomber. The Olympus family of engines started in 1947 as a design exercise for a hypothetical bomber. The first engine ran on the test bench in May, 1950, having been designed, incidentally, for 9,000 lb thrust. The first flight of an Olympus was made in August, 1952, in a Canberra flying test bed, and it flew for the first time in a Vulcan in September, 1953. The first production engine, the 11,000 lb thrust Olympus 101, was type tested in December, 1954, and extensive flight testing was carried out with the Vulcan before the first aircraft were delivered to the Royal Air Force in the summer of 1956. Over 30,000 hours of test-bench running have been carried out on the Olympus in addition to flight testing. Some idea of the cost can be gained from the fact that the Olympus uses, in round figures, 5 tons of fuel per hour.

Turning to the question of uncertainty, one can appreciate that changing requirements and the selection of different aircraft designs have a major effect on an engine programme, in addition to the possibility of there being two competitive engines for the same application. As an example, there was considerable doubt during 1956 and the early part of 1957 whether the Olympus programme would continue in spite of the needs of the V bomber programme and successful completion of the Olympus B 01 6 type test at 16,000 lb thrust in January, 1957. This doubt was only resolved by the announcement of the selection of the engine for the Vulcan Mk. 2 by the Minister of Supply in May, 1957. The history of the Orpheus lightweight turbojet is also an example of the uncertainty which may surround a project. Originally designed at the end of 1953, and first run in December, 1954, the Orpheus was only adopted for the first time for the Royal Air Force last month. Even though the development costs of a simple lightweight engine are clearly not as high as those of the Olympus, for example, it may be wondered whether any manufacturer would have been willing to back the engine as a private venture for four years. In this case, however, the engine was adopted by the Mutual Weapons Development Programme for development for the NATO lightweight strike fighters, this decision being made in March, 1955.

With regard to the Orion, the facts surrounding the recent decision to suspend development of the engine are comparatively well known. The Government decided that it could no longer support development of the engine, there being no firm requirement, either military or civil, in this country. The company was then faced with the decision as to whether or not to continue with the development as a private venture. In view of the very great cost involved—upwards of £5 million—and the absence of firm orders for production quantities, Bristol regretfully decided that they were not justified in carrying on development. The Orion was the first of a new type of engine, described as a supercharged turboprop. By this is meant that the engine was basically capable of developing 8,000 h.p. at sea level but was limited to approximately 5,000 h.p., this figure remaining constant up to a "full throttle height" which at the take-off rating was 15,000 ft. This concept had three major advantages: first, it enabled the weight of the engine to be reduced in line with the take-off figure of 5,000 h.p. Thus, as the cruising h.p. developed at 35,000 ft was almost the same as that at ground level, instead of dropping to roughly half as with a normal engine, the ratio of power to weight under normal cruising flight conditions was nearly twice that of conventional engines. Secondly, it enabled maximum power to be developed for take-off from any airfield in the world, irrespective of its elevation above sea level or of high temperature. This occurs automatically, using some of the immense reserve of power of the engine at low altitudes, and permitted full payload for take-off from any airfield. Thirdly, the engine was designed to have a cruising fuel consumption comparable with the best piston engine practice and substantially lower than that of any existing turboprop.

The Orion was intended for later versions of the Britannia and early in its history BOAC placed a letter of intent for 60 Orions to re-equip their Britannia fleet. R.A.F. Transport Command were also interested in the engine for their Britannia's. The other application was to the Canadair CL-44 (CC 106) transport ordered for the Royal Canadian Air Force. The take-off power of the Orion at sea level was 4,400 s.h.p. + 1,950 lb jet thrust, giving a total equivalent horsepower of 5,150. The power at 30,000 ft at 400 m.p.h. at the maximum recommended cruise rating was 3,960 equivalent h.p. At the same cruising speed and height the specific fuel consumption was 0·41 lb/ehp/hr.



Propeller-turbine development and prospects as they appeared when the Defence White Paper was published.

Reprints of Report of "Engineering" Inquiry into the British Aircraft Industry will shortly be available from The Publisher, ENGINEERING, 36 Bedford Street, London, W.C.2, price 4s. each post free. Special rates for large quantities. Orders, with remittances, should be sent as soon as possible.

Design

BENDING OF PRE-TWISTED TURBINE BLADES

Effect of Inclination of Longitudinal Fibres

By William Carnegie,
B.SC., PH.D., A.M.I.MECH.E.*

Pre-twisted blades find extensive use in both the turbine and the axial compressor of gas-turbine machinery. When such blades, of thin-walled section, are subjected to transverse loading, the resulting deflections are dependent on the inclination of the longitudinal fibres. The results of an analysis of this problem are presented below, the notation used being:

E, Modulus of elasticity
F, Fibre force
M_L, Lateral moment
M_x, Bending moment in x z plane
M_y, Bending moment in y z plane
m, Width of cross-section
x, Deflection of blade in x direction
y, Deflection of blade in y direction
z, Co-ordinate distance measured along blade
α, Angle of pre-twist.

It will be seen that Fig. 1 shows two blades of rectangular cross-section, having length L and a total pre-twist angle of α_L: each blade being mounted rigidly at one end, with its longitudinal axis horizontal, and being subjected to a concentrated load W acting vertically downwards at the other end. The blade of Fig. 1*a* has its broad face at the root cross-section mounted horizontally, while that of Fig. 1*b* has its broad face at the root cross-section mounted vertically. Short elements of each blade, of length dz and distance z from the roots, are shown in Fig. 2*a* and Fig. 2*b* respectively, the angle α of pre-twist increasing by an amount $d\alpha$ over the element length. Two fibres of each blade element are shown, B B above the neutral fibre A A in tension and C C below the neutral fibre in compression. The forces which cause this tension or compression are considered to act along the fibres, a valid assumption if the cross-section is thin, since the presence of forces normal to the fibres concerned is, thereby, precluded. Due to the fibres being in the form of helices, however, forces dF along them will no longer be parallel to the deflected z z axis as in the simple bending theory; thus they will have longitudinal components (dF_z), and lateral components (dF_L). The magnitudes of the fibre forces (dF) differ from those determined on the basis of the simple bending theory, with the result that the ensuing bending moments and the corresponding deflections measured along the x and y axes are affected.

The longitudinal tensile or compressive components (dF_z), when summed over the blade cross-section, have a zero resultant. The bending moments acting on the blade due to the fibre forces (dF_z) become

$$M_x = E\bar{I}_{yy}\left(\frac{d^2x}{dz^2}\right) + E\bar{I}_{xy}\left(\frac{d^2y}{dz^2}\right) . \quad (1)$$

$$M_y = E\bar{I}_{xx}\left(\frac{d^2y}{dz^2}\right) + E\bar{I}_{xy}\left(\frac{d^2x}{dz^2}\right) . \quad (2)$$

Equations (1) and (2) are the equations of the bending of a pre-twisted blade allowing for the inclination of the fibres. Hence, deflection expressions, in which the fibre inclination is accounted for, can be obtained. $\bar{I}_{xx}$ and $\bar{I}_{yy}$ are modified second moments of area and $\bar{I}_{xy}$ is a modified product moment of area; they can be readily evaluated for rectangular cross-sectioned blades.

Due to the approximations made in this analysis, however, their use is limited to thin blades where both the deflections under load and pre-twists are small. They are smaller in magnitude than the corresponding parameters applicable when fibre inclination is ignored.

* Department of Mechanical Engineering, University of Birmingham.

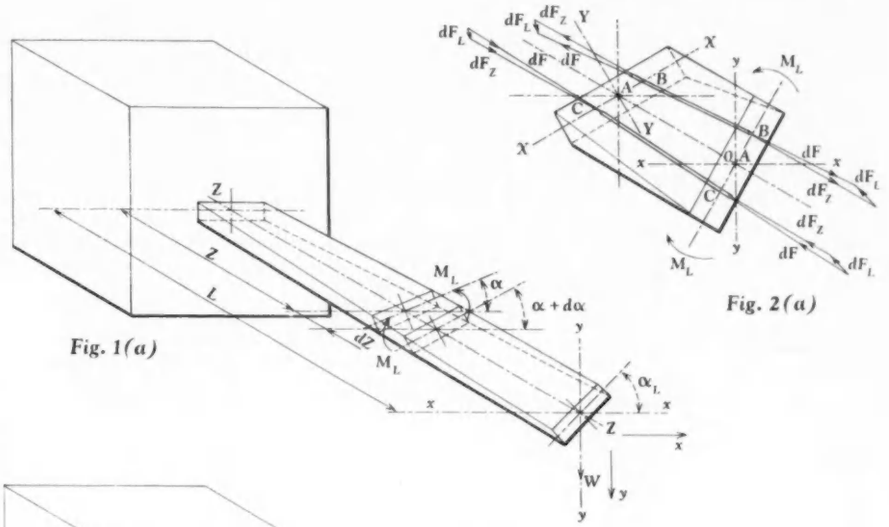


Fig. 1(*a*)

Fig. 2(*a*)

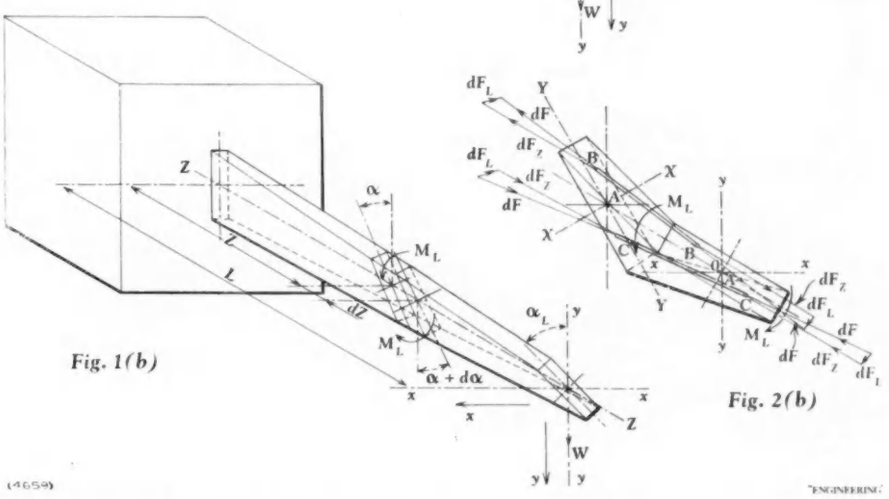


Fig. 1(*b*)

Fig. 2(*b*)

(4659) "ENGINEERING"

As a consequence, the bending stiffnesses are less than, and, thus, the deflections under bending will be greater than, those determined by the use of the simple bending theory. For pre-twisted blades whose pre-twist angles never exceed $\frac{\pi}{2}$ radians, the percentage change in deflection, due to the effects of fibre inclination on the bending moments M_x and M_y, is small and can be ignored. Accordingly, the change in magnitude, due to fibre inclination, of the fibre force components (dF_z) does not affect the blade deflections appreciably providing that the pre-twist angle never exceeds $\frac{\pi}{2}$ radians. A more extended treatment of the problem, for blades with large angles of pre-twist, is given by Zickel.[1]

The lateral shear component (dF_L) of fibre force will influence the deflections of a pre-twisted blade. Additional shear stresses result which are due solely to the inclination of the blade fibres. The component shear forces resulting from these additional shear stresses, when added to the corresponding component St. Venant shear forces in bending, must equal, on integration over the blade cross-section, the relevant external loading. For blades having pre-twist angles not greater than $\frac{\pi}{2}$ radians, the effect of the additional shear stresses will be to modify only slightly the distribution of total shear stress at any given cross-section. The deflections due to shear depend on the shear stress distribution over the various cross-sections of the blade, but such deflections are extremely small and changes caused in their magnitude by slight alterations of the shear stress distributions will be negligible. Thus, the blade deflections are not significantly altered by the direct action of the additional shear stresses resulting from fibre inclination.

Of much greater importance are the lateral moments, of the lateral force components (dF_L), acting about the centroid in the plane of the cross-section. These component moments when integrated over the complete cross-section, have a zero resultant as is required for the equilibrium of the blade. If, however, the cross-section is bisected by the shorter principal axis through the centroid, summation of the component moments acting on each of the two half sections so obtained, results in two moments (M_L, Fig. 2), of equal magnitude but opposite sign, bending the blade laterally. Hence the cross-section is deformed into a concavo-convex shape resembling that found with anti-clastic bending.

For a pre-twisted cantilever blade of thin rectangular cross-section, subjected to a transverse bending load W at its free end, the lateral

Continuing **Design**

moments M_L, to a first order of approximation, can be shown to be

$$M_L = \left[\frac{3\,W\,(L - z)\,m}{16\,L}\right] \alpha_L \sin\left(\frac{z\,\alpha_L}{L}\right). \quad (3)$$

where z is the distance measured along the blade from the root.

The use of equation (3) should be restricted to thin blades having small pre-twist angles and small deflections under load. It has been shown experimentally by the author[2] that the deflections of pre-twisted cantilever blades of small pre-twist angle are dependent on the orientation of the root cross-sections. The lateral bending due to the action of the moments M_L, if allowed for in a theoretical analysis, will modify the calculated deflections in a manner consistent with the measured observations for each of the two blades investigated. It is suggested, therefore, that the discrepancies observed between the theoretical and measured deflections, evident in the above-mentioned investigation, are caused by the lateral bending action of the moments M_L, and, as a consequence, the discrepancies are due to inclination of the longitudinal fibres.

REFERENCES

[1] J. Zickel, "Bending of Pre-Twisted Beams." *Journal of Applied Mechanics*, Vol. 22, No. 3, p. 348 (1955).

[2] W. Carnegie, "The Static Bending of Pre-Twisted Cantilever Blading." To be published in the *Proceedings* of the Institution of Mechanical Engineers. (See *The Chartered Mechanical Engineer*, p. 299, June (1957).

Photocopies of the complete paper, of which the above is a digest, are obtainable from the Publisher, ENGINEERING, 36 *Bedford Street, Strand, London, W.C.2, price* 20*s., each, post free.*

CONTROL OF BACK-PRESSURE TURBINES

Speed and Pressure Systems

For steam turbines rated at 800 and 5,000 kW, the VEB Turbinenfabrik, Dresden, employs oil-hydraulic control. The construction of this control allows for wide adaptation to prevailing operating conditions by working on the unit-assembly principle. High sensitivity and rapid setting of the regulator afford proper and exact regulation even with high turbine speeds. As a result of variations of pressure of the control oil, the speed regulator or the pressure control supplies the regulating force. This kind of regulation is used in basically similar designs for back-pressure turbines driving generators, pumps, condensers or blowers. The following description of the method of operation refers to the accompanying diagram. When the pressure control is cut out the valves V_1 and V_2 are closed. To show the circuits clearly, two views of the regulator are given below.

The regulating process for a back-pressure turbine adjusted to run at constant speed takes place as follows. When the speed of the turbine increases, due to reduced load or increased supply of energy, the speed regulator, which is driven through gearing from the turbine shaft, opens the control slot *a*, the amount being determined by the instantaneous value of the centrifugal force acting against a spring. This action causes a reduction in pressure of the control oil and permits the pilot piston S of the servo-motor to be displaced from its mid-position, opening channel K_1.

The force which is exerted by the pressure oil from below moves the main piston P upward. Working through a system of rods and a control shaft this closes the steam jet valves until the reduced steam supply has equalised the increase of speed, and the balance between load and output is restored. At the same time the main piston of the servo-motor moves the return lever R_1 by means of a conical cam, reducing the pre-load of the return spring F_2 until the pilot piston S has returned to its mid position and the regulating process is completed. To avoid steady-state wear the main piston is kept continuously rotating very slowly.

In the case when the turbine is subjected to an increased load with a consequent fall in speed the regulating process is similar, but in reverse. The pressure of the control oil increases due to the closing of the control slot, a, and the pilot piston moves to give access for the pressure oil to the space over the main piston; thus the steam-regulating valves are opened.

By means of tensing or releasing the regulator spring F_1 with the angle lever WH, the nominal speed of the turbine can be adjusted when it is running as a single unit (see both longitudinal and cross-section diagrams of the regulator block). During generator parallel operation a change of the steam throughput and thus of the output can be attained by the same process. The loading of the regulator spring is effected by a worm gear from the manual adjustment HV or by an electric motor EV if remote control is desired. The proportional range can be adapted to prevailing circumstances and stability conditions by changing the regulator spring F_1; springs of various characteristics are available. For back-pressure turbines in excess of 800 kW four regulating valves are used which open and close successively according to the load. The regulating ranges of the groups overlap somewhat to ensure smooth transition from one

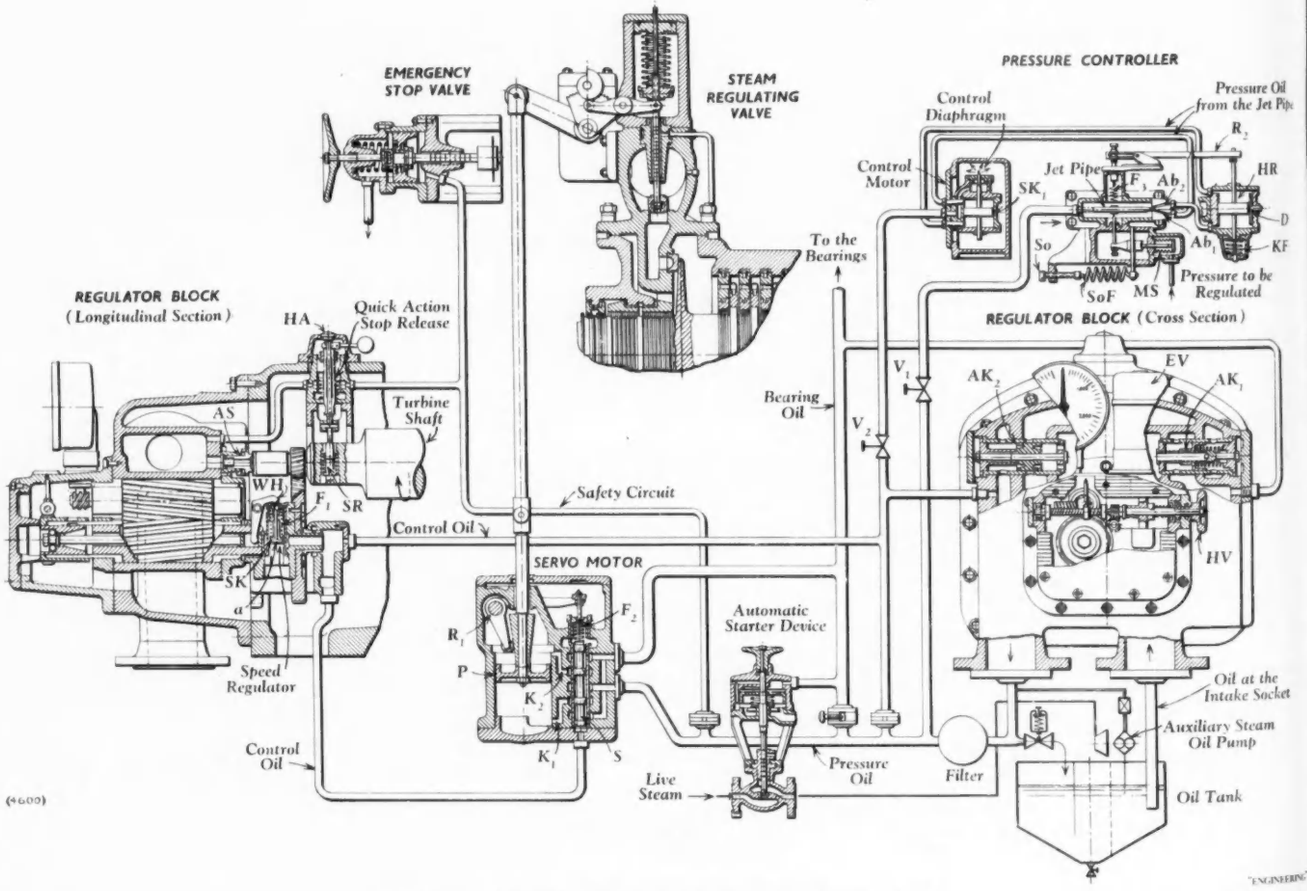


Diagram of control system for back-pressure steam turbine.

group to another. The last valve is used mainly for attaining the peak load condition and remains closed up to normal full load.

Very often it is required that the turbine is not only provided with speed regulation but also with pressure control. For this purpose the pressure regulator illustrated at the upper right-hand corner of the drawing is provided. With pressure control in operation the regulating process proceeds as follows:—

The bellows MS attached to the control system are subjected to the pressure to be regulated, e.g., to the back-pressure of the turbine, and is balanced by the adjustable spring, SoF, and the return spring F_3. The piston of the hydraulic return HR is kept in mid position with the aid of the coil spring KF. When the pressure increases in the exhaust steam line, due to reduced steam consumption, the bellows are compressed and the jet pipe is moved to the right by means of a lever mechanism. This causes an increased amount of pressure oil to flow through the pick-up channel Ab_1 and the control piston SK_1 to move downwards. The control diaphragm is further opened by this process, the pressure of the control oil drops and the regulating valves close. This condition remains until the balance is restored. Due to the pressure difference developed between the two pick-up channels Ab_1 and Ab_2 the hydraulic return HR moves in the direction of the coil spring KF and releases the return spring F_2 over the return lever R_2 until the jet pipe has again resumed its centre position. If a differential regulator is used, i.e., a regulator mechanism with constant pressure-difference between loaded and no-load turbine, the regulating process would conclude with this. However, with the pressure control system employed, the remaining pressure-difference is eliminated by means of the automatic post-regulation of the hydrauiic return (integral effect).

This action proceeds as follows. After the steel jet pipe has returned to its centre position, a slow pressure equalisation between the two oil chambers of the return HR is effected through the throttle D, and the coil spring KF can press the return piston into its centre position—that is, the return spring F_3 receives the same pre-load as before the start of the regulating process. This means that the balance of the regulator is restored only if the same pressure value as previous to the disturbance has been attained. For the case when the back-pressure drops, the regulating process is reversed and the valves are opened.

The turbine is governed either by the speed regulator or by the pressure controller, but both cannot be in action at the same time. When under pressure control, the speed regulator is set to act as an overspeed trip only. The turbine is always started with speed regulation in operation—that is with valves V_1 and V_2 closed. After the turbine has been run up to speed and put on load the valve V_1 is opened and the spring SoF set a little in excess of the normal operating pressure. This causes the control piston SK_1 to move into its top position, when the valve V_2 can be opened to release the control oil, thereby setting the pressure control regulation in operation. At the same time, the speed regulator is turned to its top stop so that it has no more effect upon the pressure control but acts only as speed limit regulator in case of a sudden increase in turbine speed as when, for instance, the load is suddenly removed.

The automatic starting device shown in the diagram serves to start and stop the auxiliary steam oil-pump. This ensures a continuous supply of oil even if the safety devices should suddenly put the turbine on standstill condition and the regular oil supply be interrupted.

The safety circuit operates the emergency stop valve to bring the turbine to rest immediately. This can be brought into action by :

1. Over-speed of the turbine, by means of the valve SR. This is set for about 10 per cent above the rated speed; 2. Upon a drop of the bearing oil pressure below 0·4 at. gauge; 3. Upon excess axial displacement of the rotor, by means of the axial protection AS; 4. Upon operation of the manual release HA.

A fall in the bearing oil pressure acts on the piston AK_1 directly, but the piston AK_2 moves to the right only after the stop valves have acted and the pressure in the safety circuit fallen, freeing the drain holes. This causes the pressure of the control oil to drop also and the regulating valves close. Thus the live steam supply is doubly blocked.

EASTERN REGION DIESELS

The first of ten 2,000 h.p. diesel-electric locomotives built by the English Electric Company Limited (at Vulcan Foundry) for the Eastern Region of the British Railways has recently run from Liverpool Street to Norwich (Thorpe) and back. Already running on this route are some of the Brush D5500 locomotives, and with the introduction of the summer timetable on 9 June, a large part of the express main line service to Norwich will be diesel hauled. The Britannia class locomotives so released will be used to provide an improved service between Liverpool Street and Clacton. Steam working will have disappeared from Liverpool Street and Stratford motive power depot (formerly the largest steam depot in the country) by 1961. By that date there should be 232 main line diesel locomotives in service in the region.

The English Electric locomotive D200 shown in the illustration is driven by a type 16SVT mark II engine rated at 2,000 h.p. at 850 r.p.m. This is a four-stroke V engine supercharged by Napier blowers. The body and underframe are a single fabricated stressed unit and are mounted on two four-axle bogies. These are similar in design to those already in service on diesel-electric locomotives running on the Southern Region, and have a ICo-CoI wheel arrangement. In working order, D200 weighs 133 tons and develops a maximum tractive effort of 52,000 lb, falling to 30,900 lb for the continuous rating. Maximum speed is 90 m.p.h. The length over the buffers is 69 ft 6 in and the driving wheels are 3 ft 9 in in diameter.

The six motors are nose suspended and axle hung; they are rated at 600 A at a voltage of 300. They drive through single-reduction spur gearing. To extend the range of speeds over which full power is available (the motors are series wound) provision is made for three stages of field weakening, using diverter resistances. The motors are connected across the main generator in pairs in series, the three pairs being connected in permanent parallel. Field weakening is automatically introduced by the torque regulator and again is automatically suspended when engine loading becomes excessive. The engine speed is continuously varied from 450 to 850 r.p.m. and the loading is automatically adjusted so that it delivers maximum power corresponding to the selected speed.

An auxiliary generator driven from the free end of the main generator supplies such items as the exhausters, motor cooling blowers, and battery charging equipment. The exhausters are mounted in the two noses and are arranged to run at two speeds: low for general purpose and fast for occasions when a quick release of the brakes is required. Water for the train heating boiler is contained in an 800 gallon tank slung between the bogies and can be replenished from water troughs by scoop. Toilet facilities and a breakfast cooker complete the amenities of the locomotive.

The first of ten 2,000 h.p. diesel-electric locomotives for service on the Eastern Region.

SCANNING CORRELATOR FOR AERIAL SURVEYING

An automatic electronic scanning correlator for stereo-images, described by Canadian and United States Government specialists as "a major break-through in the science of aerial mapping," has been developed by the Photographic Survey Corporation, Toronto, Canada. The device speeds up the process of obtaining information from photographs up to 100-fold.

The new device, known as "Auscor" (automatic scanning correlator) was invented by Mr. G. L. Hobrough. By a system of electronics and electro-mechanics, Auscor senses the relative displacement of images in two vertical aerial photographs taken from different positions but having overlapping fields of view. Up to now, the perception of three-dimensional effects in what are called "stereo pairs" has been by human operators using plotting machines. The Auscor automatic method has proved to be comparable with human operators, and is free of the fatigue factor which applies to operators performing such tedious routine. Although it is expected that the device will require monitoring, a single operator will be able to attend to a battery of machines.

Adapted to a Kelsh Plotter stereo machine, Auscor measures the relative heights of image detail after adjusting the stereo pairs automatically to correspond to their relative positions when the photographs were taken.

Engineering at Home

INTEGRAL LIGHT-ALLOY CARAVAN

There is still scope for ingenuity and improvement in the design of trailer caravans. Adequate structural strength with lightness, good towing, and riding characteristics combined with all the qualities that make for a comfortable residence such as weatherproofness, durability, freedom from condensation and a high standard of thermal insulation, have to be provided at minimum production costs. The materials must also be selected with an eye to exterior finish and interior decoration.

The prototype trailer caravan demonstrated by the British Aluminium Company on 23 April indicated how a combination of high performance with good living standards could be achieved by a new approach to design. The caravan had been built by Pemberton Caravans Limited, Wigan, Lancashire, and the internal fittings, including the furniture, curtains, gas stove and other items, were similar to the builder's current range of caravan production. In general appearance, the caravan was similar to any conventional trailer caravan, with the exception that embossed aluminium sheet was used for the panels.

The structural design, however, which had been produced by the road transport engineers of the British Aluminium Company's development department, was completely new. In order to make the most effective use of aluminium alloy, the conventional light steel chassis with axle and wheels, the towing hitch and corner support jacks, to which a separate body is attached, had been replaced by a chassisless integral form of construction. A new form of trailing-link independent suspension unit, devised by Peak Trailers Limited, had also replaced the more usual beam axle with semi-elliptic springs. Together with Armstrong coil springs and damper units this suspension provides a good ride on rough road surfaces.

Details of construction are shown in Fig. 1. The main structural member is a hollow box-section running fore and aft below the centreline of the floor and fabricated from two Z's a channel and flat base extruded sections in the structural aluminium alloy BA25 (B.S. 1476, H10-WP). Across this box-section is the floor structure which is a "sandwich" of "Rigidal" corrugated aluminium sheet, with plywood on top and sheet aluminium below; the corrugations of the "Rigidal" sheet run transversely to provide stiffeners in this direction. Additional strengthening of the wheel base is provided by transverse and longitudinal extruded channel sections. The wheelboxes were fabricated from 14 s.w.g. BA25 WP sheet and are actually load carrying. The body of the caravan is stressed, the body sides, which are attached to the floor through a deep skirt rail, and the centre hollow box section, provide longitudinal stiffness.

The sides, ends and roof of the body are insulated, and a special new pillar construction has been used in which two aluminium angle sections are joined at intervals along their length by non-conduction hollow section spacers. In this way light, strong pillars have been constructed with no metal to metal paths through the sides which would encourage condensation.

The outside of the caravan was panelled with unpainted embossed aluminium sheet in alloy BA21 (B.S. 1470, NS4), apart from a band along each side which was coloured maroon for decorative purposes. This band was edged top and bottom with a moulding in super-purity aluminium which had been given a brightened and polished finish. The embossed pattern of the exterior was most attractive and a considerable improvement over the bright metallic appearance of normal cold-rolled sheet; there was also the additional advantage of reducing glare from reflected sunlight and of being less susceptible to streakiness and weather-staining. For the interior, use had been made of leather grain embossed sheet painted an ivory colour.

It is classed as a four-berth touring model 15 ft in length, 7 ft wide and internal headroom of 6 ft 3 in. The overall weight has been kept within 1 cwt per ft length, and tests of the original prototype unit successfully carried out by the Motor Industry Research Association at their proving grounds and elsewhere at speeds up to 73 m.p.h., have shown that the body construction is particularly robust.

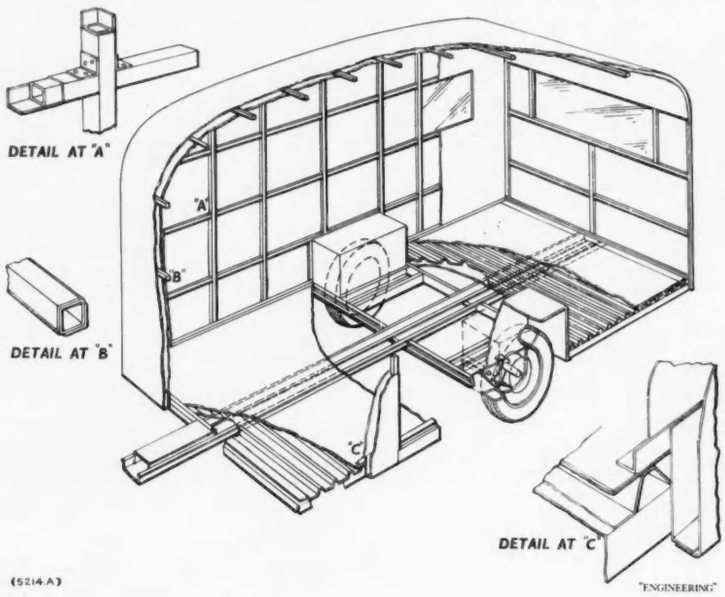


Fig. 1 (left) Construction details of Pemberton Integral Caravan showing fore and aft box-section, pillow sections and "sandwich" form of floor construction.

Fig. 2 (right) Interior showing furnishings and leather grain embossed aluminium sheet panelling finished with ivory coloured paint.

Fig. 3 The caravan's exterior is unpainted embossed sheet panelling with a maroon coloured band of the same sheet, trimmed with brightened and polished extruded moulding section.

ENGINEERING

Published every Friday by ENGINEERING LTD. at 36 Bedford-street, London, W.C.2.
Telephone: Temple Bar 3663.
Telegrams: Engineering Lesquare London.

CHAIRMAN: J. A. Dixon, M.A., A.M.I.Mech.E.
EDITOR: F. B. Roberts, M.B.E., A.M.I.Mech.E., A.M.I.Loco.E.
DEPUTY EDITORS: D. Fisher, Ph.D., B.Sc., A.M.I.C.E., A.M.I.Mech.E.; E. P. Ward, M.A., A.M.I.Mech.E.
ASSISTANT EDITORS: E. I. Brimelow, M.Eng., Assoc.I.Mech.E., A.I.M.; J. E. Dodsworth; W. K. V. Gale, M.I.S.I.; J. T. Godfrey; R. Lemmy, A.I.M., M.I.S.I.; M. Neal, B.Sc., D.I.C., A.F.R.Ae.S.; R. G. Pay, M.Sc.; A. A. H. Scott, B.Sc., A.M.I.Mech.E.
SUBSCRIPTION MANAGER: G. A. Roberts.
ADVERTISEMENT MANAGER: G. H. Dixon.

Annual subscription rates: Inland and abroad £5 10s. (Canada, £5 5s.). Three months, 27s. 6d. all countries. Single copies, 2s. 7d. post free.

Engineering Information Service: Assistance is available from Engineering Information Service in obtaining information, and in locating sources of information, both technical and commercial. E.I.S. deals with, for example, names of makers and suppliers of plant and equipment, technical data on design, markets for engineering products, and compilation of references to information on specific topics. Inquiries should be addressed to Engineering Information Service at the address given in the left-hand column.